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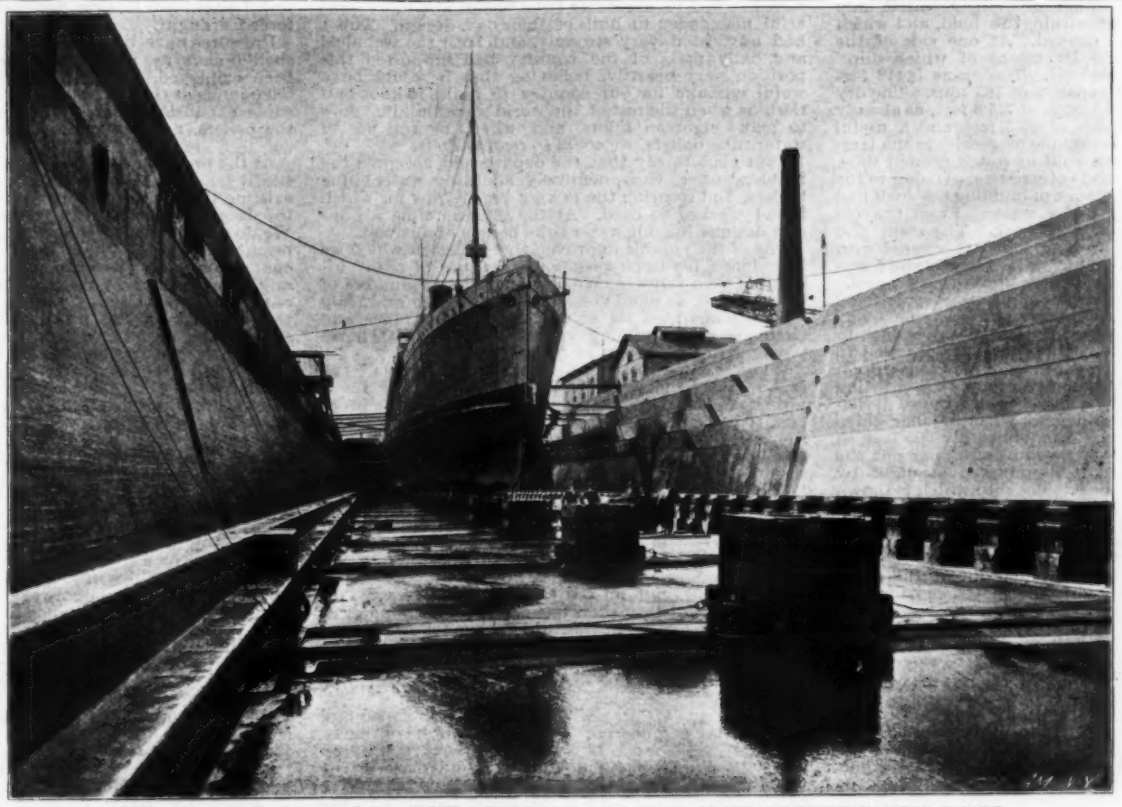
THE NEW BREMERHAFEN DRY DOCK.

THE rapid growth of German shipping within the last decade is due largely to the enterprise of the merchants of the free cities, Hamburg and Bremen. The praiseworthy energy shown by the town of Bremen in building wharves and docks has culminated in the construction of the giant Kaiserhafen dock at Bremerhafen, a suburb of Bremen.

The Bremerhafen dock is the largest of its kind on the continent of Europe; it is equaled in size by a few English docks and surpassed only by the 960-foot dock of Liverpool. The new dock is an addition to the Kaiserhafen (Kaiser Basin), built in 1890-97. When the basin was first begun, it was evident that a new dry dock would soon be required to accommodate the huge vessels of the great steamship companies, and particularly those of the North German Lloyd. Each new vessel surpassed its predecessors in length, until finally the companies were compelled to turn to England for adequate docking facilities. Moreover, the German navy, constantly growing in numbers, required better docking accommodations for its new vessels and above all for its more recent battleships. Naval dry docks of any size were to be found only in Kiel and Wilhelmshafen. Besides these docks there were merely a few floating and a few wooden dry docks distributed along the northern coast. The War Ministry saw the necessity of better facilities and entered into an agreement with the municipality of Bremen to build in conjunction with the city a dry dock having a useful length of 525 feet and a width of 82 feet. The naval officials stipulated that the government's vessels were to have the same privileges as those of the North German Lloyd and were to be given precedence over all foreign ships. In time of war even



THE STEAMER "PRINZ-REGENT LUITPOLD" IN THE NEW BREMERHAFEN DOCK.

THE SOLE OF THE BREMERHAFEN DOCK—KEEL AND BILGE BLOCKS SUPPORTING THE "PRINZ-REGENT LUITPOLD."

the North German Lloyd was to give way to the navy. For these privileges the government agreed to pay 2,400,000 marks ($600,000) of the total cost, $1,250,000. The North German Lloyd agreed to lease the dock for twenty five years at an annual rent of 120,000 marks ($30,000) and to keep the dock in repair. Before work was begun it was decided to increase the length to 656 feet. But the newly completed "Kaiser Wilhelm der Grosse," which very nearly reached this limit, necessitated another increase, which brought the length of the dock to 721·6 feet. Originally pumps of 800 horse power were specified. But the increased size rendered a horse power of 1,200 necessary. The cost of the dock was increased $225,000.

The new dock runs north from the Kaiserhafen. The entire docking plant consists of an outer basin, a repair basin, and finally of the dry dock itself. The repair basin, in which two vessels respectively 650 feet long and 500 feet long can be simultaneously moored, is intended to receive ships which are to be repaired only above the water line or within the hold, and which need not, therefore, be docked. At one side of the basin is an electric crane by means of which ships' boilers are raised and lowered. The crane is 118 feet high, and has a lifting capacity of 165 tons. The dry dock proper has a useful length of 715·6 feet, as already remarked, a central width of 90·5 feet, and a useful depth of 31·5 feet. It is capable of receiving the largest ships which have been built up to the present time. The sole of the dock is made of concrete. Owing to the character of the soil, the work of building the dock had to be performed largely under water. From the sole rise concrete walls faced with brick. The steps and the upper ends of the retaining walls are covered with granite. One hundred and forty keel blocks and forty-four bilge blocks are provided for supporting a vessel.

The pumping plant consists of two large centrifugal pumps, each driven by a 600 horse power engine. The two pumps are capable of emptying the entire dock in two and one-half hours. At the dock entrance are two cranes, each with a lifting capacity of fifty tons; upon the caisson gate is an auxiliary crane with a lifting capacity of twenty tons. These cranes are all driven by electricity. The caisson gate, when smaller ships are to be docked, can be shifted inwardly 200 feet, so that considerable time is saved in pumping out the water. The entire plant is illuminated at night by twenty 12 ampère arc lamps. The ship which is shown in the dock is the North German Lloyd steamer "Prinz-Regent Luitpold," which, although not one of the largest steamers owned by the company, is nevertheless a goodly sized vessel of 3,920 tons displacement with a length of 455 feet. For our illustrations and particulars we are indebted to the Illustrirte Zeitung.

[Continued from SUPPLEMENT, No. 1249, page 20018.]

ENGINEERING IN THE UNITED STATES NAVY—ITS PERSONNEL AND MATERIAL.*

I BELIEVE it is generally admitted that the machinery of our navy has been in all respects fully abreast of the latest developments, and in many respects we have taken the lead. One of the first things which may be mentioned is the fact that, during the period before water tube boilers were used in any navy, and when in some foreign navies there was a great deal of trouble with the shell boilers, due to the effort to get an abnormally large amount of work out of them, we had no such trouble. We believed in the principle of never sending a boy to do a man's work, and, as a result, we never had a boiler incapacitated through leaky tubes, and never lost a trial trip on this account, while failures of this sort were very common things abroad.

One of the first things we did was to establish the use of water tube boilers and light compound engines for our steam launches. Private builders in this country had used water tube boilers, but the results, owing to the type of boiler employed, were not altogether fortunate. We found a boiler which has proved entirely satisfactory, and also developed light machinery which was also sufficiently substantial to stand the comparatively rough handling with which the machinery of small boats must inevitably meet. We are to-day the only navy which uses water tube boilers exclusively in its small boats. When we started, the effort was made to save as much water as possible, and small blowers run at a high speed were used for draught, but the inevitable hum caused so many objections to be entered by officers of high rank, that we were driven to the use of the steam jet. It was, of course, important that the most economical form of jet should be used, but when we came to determine this question, we found that there were absolutely no reliable data in existence. As a result, we carried out a valuable series of experiments at the New York navy yard, and found an exceedingly simple form of jet, which was also very economical, giving us a fairly high rate of combustion for a comparatively small expenditure of steam.

It was evident to us that with the prevailing tendency toward continual increase of speed and power, with the accompanying increase of steam pressure, the shell boiler would at some near date have to be superseded by the much lighter water tube boiler, and we therefore invited a competition among the various manufacturers of water tube boilers, with a view to determining the one which, all things considered, would be best adapted to naval uses.

Although this competition occurred about ten years ago, you are doubtless familiar with the circumstances, and that, as a result, we installed about 5,000 horse power of Ward boilers in the coast defense vessel "Monterey," this being at the time, and for several years, the largest installation of water tube boilers in any naval vessel. I am glad to say that these boilers have always given satisfaction and are still in use. At this same time, water tube boilers of a different type were installed on one of our torpedo boats, and we have never used any other than water tube boilers on any of the numerous torpedo vessels which have been built since.

It would have been an easy matter, and it would have brought temporary praise to the engineer-in-chief, if, after the successful trial of the "Monterey," we had at once launched out into the use of water tube boilers for all our vessels; but we felt that there had not been sufficient experience in their use to warrant us in making such an experiment in our first seagoing armor-clads, and, consequently, for a number of years, and even after foreign navies had begun to use water tube boilers extensively, we continued to use the shell boilers in our large vessels.

Two years ago, when I felt that there had been sufficient experience to warrant us in the final adoption of water tube boilers, I recommended in my annual report to the Secretary of the Navy that we should definitely adopt water tube boilers for all classes of vessels. For reasons altogether apart from the machinery, we were not at first successful in securing water tube boilers in the department's own designs, in spite of my urgent recommendations, but the firms which tendered on the government's designs also offered to guarantee higher speeds if they were allowed to use water tube boilers and more powerful machinery in hulls of their own design. This I had advocated very strongly, and both the technical and daily press of the country had supported this position very heartily, believing that it would be a woful mistake for our country to build 16-knot battleships when the rest of the world were building ones to make eighteen knots, and when, by the use of water tube boilers, we could so readily do it.

I am glad to say that the department accepted the builders' offer, thus definitely adopting water tube boilers, and securing the 18-knot battleships for which I had worked so hard. At the present time all our new designs include water tube boilers exclusively.

One of the notable improvements in design which we introduced for large vessels was the use of triple instead of twin screws. We were not the originators of this method, as small vessels in both France and Italy had demonstrated its success, and both France and Germany were building vessels of about 12,000 horse power with this system of propulsion.

When it came to the design of the "Columbia," the first of our commerce-destroyers, with 21,000 horse power, I was satisfied, after careful study of the problem, that we would need to use triple screws to attain success. At the beginning I did not anticipate an economy in propulsion, and the adoption of triple screws was for structural reasons; but when the "Columbia's" trial occurred, we found that there was a material increase in the propulsive efficiency. When the "Minneapolis" was tried shortly afterward with the same system of machinery, this fact of greater economy was again established, so that we now feel that triple screws are justified, not only for numerous other reasons, but on the ground of economy. This arrangement of propellers has become very popular in a number of foreign navies, which have followed it out on a considerable scale, and have built all their large vessels with triple screws. It is probable that we shall do the same thing in our larger ships of the new programme.

During our late war with Spain we developed and utilized two engineering schemes which have never previously been tried in actual service—a repair ship and a distilling ship. The former is one phase of the modern method of treating large work by taking the tool to the work instead of bringing the work to the tool.

The "Vulcan" was the equal of anything except a very large repair yard, and after the battle of Santiago she was almost invaluable in the much needed general overhaul of all the ships. Besides an admirable outfit of machine tools and engineering stores, the "Vulcan" was specially notable for using the first cupola ever installed on board ship.

The distilling ship was fitted with a four-unit, triple-effect distilling apparatus, capable of furnishing 50,000 gallons of fresh water per diem after use for some time with an economy of over 20 pounds of water per pound of coal burned under the boilers.

With clean coils the "Iris" actually furnished over 100,000 gallons per diem. The bunker capacity is 3,000 tons of coal, thus giving a potential capacity of distilled water of 60,000 tons, or as much as twelve of the largest tank steamers. The advantages of a distilling ship over a "tanker" are very numerous and obvious.

The war with Spain was too short to give a chance for great experience in any line, but the work of the "Oregon" stands out as a brilliant illustration of the fact that the modern battleship is not only the creature of the engineer, but is absolutely dependent upon him for success. You all know the story of Milligan's work as the chief engineer of the "Oregon," of his ceaseless vigilance to keep everything in order and prevent any deterioration, of how he saved the good coal for the day of battle, which finally came (though he was told it never could come), and above all how he persuaded Clark, the commanding officer, to have all the boilers ready all the time, although others had steam on only half the boilers, and where it could be done half the engine power was laid off. I am firmly convinced that the brilliancy of the victory at Santiago is largely due to Milligan's skill and foresight, and, as I said above, this case is direct proof that however admirable as a great fighting machine, the battleship is useless except in the hands of trained engineers.

During the last fifteen years naval engineering has shared in the general progress of all marine engineering, and has led in many respects. Wrought iron, which was formerly the mainstay of the designer, has practically disappeared, to be succeeded by mild steel, which is not only stronger but much more reliable, and the manufacture and inspection of which has been brought almost to perfection. There is little doubt that the great improvements which have been made in both engines and boilers would have been impossible but for the greatly improved material. One of the greatest improvements has been in the reduction of weight of machinery, and this has been due both to improved material and to radical changes in design.

In the engine there has been a better disposition of the material, and the use of hollow instead of solid shafting and other large pieces of forged material, the use of steel castings, etc., has been instrumental in enabling the use of higher pressures, and particularly of higher rotative speeds. These rotative speeds have become possible since we have learned to design the propellers on rational principles. In the old days, as you are well aware, the rule was to make a propeller as large as possible, consistent with immersion, and this, on account of the empirical rules for the ratio of pitch to diameter, necessarily kept down engine speeds. Now we know that within reasonable limits we can design a propeller to suit almost any engine speed, consequently we are left free to adopt as high a rotative speed as is desirable and consistent with safety, assured that we can afterward design an economical propeller to fit it.

In the boilers the reduction of weight has been due, apart from the more recent adoption of the water-tube type, to improved material, and especially to forced draught. This, as you are doubtless aware, is an American invention almost contemporaneous with Fulton's early steamers, but it had almost disappeared, and after a brief revival under Isherwood during the civil war, had again died out until it was taken up in some of the foreign navies. At the present time no naval machinery is ever designed without the use of forced draught.

Pressures have been gradually rising, and even with shell boilers as high a pressure as 200 pounds has been employed, but with the present plans of using 250 pounds at the engine, with either triple or quadruple expansion, and some 25 or 50 pounds more at the boilers, nothing but the water-tube boiler would do.

At the present time it seems as though we had practically reached the highest development possible with existing types of machinery for naval purposes, leaving the designer room only for greater perfection in details. We do not, of course, believe that finality has actually been reached, and it is possible that some radical change may take place which will give us a new type of machinery. Some of the more enthusiastic members of the profession think that the steam turbine is to be the successor of the present steam engine, and assuredly the performance of Parsons' "Turbinia" is sufficiently remarkable to justify the most careful study and further experiment. It is very interesting in this connection to know that in this country the development of the steam turbine is in the hands of one of our famous engineers, who is also one of the honorary members of this society, Mr. George Westinghouse. He has been developing the steam turbine with special reference to its use in driving electric generators, and some of the results already obtained are very remarkable. With his characteristic energy and courage, he is not satisfied with results on a small scale, but is now getting out a steam turbine to develop about 2,000 horse power on a single shaft, and when this has been built and thoroughly tested we shall be in a position to appreciate more thoroughly the bearing of this form of prime mover on naval engineering.

At the beginning of this address it was remarked that this was a peculiarly appropriate time for discussing the personnel of naval engineering, on account of the radical change which took place this year in the status of the engineer officers of our navy. For many years, as you all know, there had been an unfortunate controversy in our navy, known as the "line and staff fight," resulting from the fact that the line officers, as the older organization, were unwilling that the staff, and especially the engineers, should have all the rights to which the latter believed themselves, as naval officers, entitled. The great grievance of the engineers was that they held what was called "relative rank" and were denied the command of their men and a military title, so that there was always room for the statement, which unfortunately was made at times, that they were not really officers and had only a quasi rank. All men who have passed middle age have probably realized personally the difficulty of bringing about any radical change in existing conditions of long standing, and I really believe that the trouble in the navy was largely a matter of inertia. An enormous amount of valuable effort was wasted on both sides, the one to secure the coveted rights, the other to prevent this result, but matters had been shaping themselves for a considerable time so as to make a new state of affairs inevitable.

The change in the means of offense on board ship had brought the line officer to the point of realizing that he must of necessity be a good deal of an engineer, and such work as the manufacture of guns, which is, of course, purely mechanical engineering, showed this very strongly. On the other hand, the work of the naval engineer on board ship, which had originally been to direct a very few men with small machinery, has been gradually changing until on some of our large ships the chief engineer commanded in fact, although not in name, about half the crew, consequently his duties had become very largely executive and military, and thus of the same nature as the duties of the line officer. As a result of this state of affairs, many of the more liberal minds on both sides believed that the solution of the vexed question in the navy was the consolidation of the line and engineer corps, and making the new line officer an engineer as well as a sea warrior, or as Congressman Foss expressed it, a "fighting engineer."

A board of naval officers, presided over by Col. Roosevelt, then Assistant Secretary of the Navy, finally formulated a scheme for carrying out this idea of amalgamation, which was actually proposed in the board by a line officer (Capt. Evans). When it was submitted to Congress, two members of the House Naval Committee, Hon. George E. Foss and Hon. A. G. Dayton, took up the measure very actively, and with the assistance of other members of the committee pushed it forward to complete success, until the personnel bill became a law, March 3, 1899.

Under the provisions of this law the officers of the engineer corps were transferred to the line and given new commissions as line officers with actual rank, thus effectually disposing of the phantom of relative rank. I wish particularly to emphasize the fact that the basis of the law, and the consideration that led to its adoption, was the demonstrated fact that to have a successful navy every line officer must be a thorough engineer. This was very well phrased by Col. Roosevelt in his report of the findings of the personnel board, where he said, "Every officer on a modern war vessel, whether he wants to or not, must in reality be an engineer." Mr. Foss, in his report to the House recommending the passage of the bill, used language of the same import, and elaborated the matter still further, and in the speeches on the floor of the House this was the subject

* Annual address by President (Rear-Admiral George W. Melville, U. S. N.) of the American Society of Mechanical Engineers. New York, December 4, 1899.

which had most weight and which brought about the passage of the measure.

A natural inquiry on your part will be, how successful is this measure in actual practice? To this the answer is that any such change must of necessity require time, and it is too early yet to speak of results. I wish, however, to put on record my opinion that if the administrative details necessary to carry the law into effect are worked out with an honest desire to give due effect to its plain intent, and with a desire to make it a success, the results will be all that can be wished and we shall have the most efficient navy in the world. If through any unfortunate combination of circumstances, which, however, I can hardly believe possible, there should be any temporary indifference or opposition on the part of those in authority, the result can only be lack of efficiency and disaster in case of war until the intent of the personnel board and Congress is put into working effect.

It may occur to some who have only looked into the matter hastily that this scheme of amalgamation is contrary to the spirit of the age, with its tendency toward specialization, but, as an actual fact, the reverse is true. The misapprehension comes from a failure to thoroughly consider the case. When it is proposed to make every naval officer an engineer, we mean an engineer especially fitted for the work to be done in the navy, just as the other training of the line officer is for the duties which come specially to him; in other words, this new line officer, the "fighting engineer," is to be a specialist in the very best sense of the term, that is, a man who has been specially and thoroughly trained for the work he has to do.

I think we may all feel a pardonable pride in this change in the status of our naval engineers. The amalgamation is analogous to that which occurred in the British navy just after Cromwell's time, and the analogy is not a fanciful nor forced one, but is strictly accurate. Up to the time of that change, naval vessels were manned by soldiers, who did the actual hand to hand fighting, but were entirely ignorant of seamanship, and another set of men who managed the propulsive power of the vessel, which was then the wind acting on the sails, and who directed the movements of the vessel. These men had no military rank, and were designated simply by professional titles, being known as "the sailing master and his mates." The amalgamation which then occurred was of the soldier and the sailor, and out of this amalgamation was evolved the man-of-war's man and the naval officer. With the advent of mastless ships, we had reached an analogous condition, where one set of people fought the guns and another set managed the propulsive power, this time steam acting through machinery. The new amalgamation has made a new naval officer, the "fighting engineer," to be followed in time by the successor to the old man-of-war's man, who will be the "fighting mechanic." The basis of the new amalgamation is the fact that in this industrial age engineering and mechanical skill are the source of efficiency in our navy, and this, as I have said, is a pardonable cause of pride to all of us as engineers.

In the past, engineering has been hampered at times in our navy on account of the subordinate position which its representatives held in the naval organization; but in the future, as the whole body of naval officers will be engineers, we have every reason to anticipate an era of progress and efficiency greater than has ever been known in the history of navies.

This address has grown to a length which I hardly anticipated when I began, and for which I ask your indulgence, trusting you will agree with me that the importance of the subject and the opportunities of the occasion excuse the extent of the address. We of the old school have lived to see our fondest hopes realized in the proper recognition of our beloved profession before we have actually ceased to participate in its active work. We linger with fond memory over our trials and discouragements, as well as our successes, and we may perhaps realize that some of our successes have been due to the stimulus of opposition; nevertheless, it does not make for success that when one is honestly doing his best work he should feel that much of it may be in vain on account of senseless opposition and failure on the part of those in high places to appreciate it; and as we older men leave the scene of action and pass on our work to the younger generation, we can congratulate them heartily on starting out under circumstances which are so infinitely better than those of our time and which give them so much greater opportunity for highly efficient work for the republic.

I thank you very sincerely for your patience in listening to this long address, and also for the kind consideration which you have all shown me during my term of office as president. I wish also to express my gratitude to those who have been office bearers with me for their co-operation, and particularly to our most efficient secretary, Prof. Hutton, to whom the society, and every president, owes so much.

SUGGESTIONS AS TO IMPROVED APPLIANCES FOR LAUNCHING SHIPS' BOATS.*

By JOHN HYSLOP, Esq.

IT is a characteristic of the present time which forces itself upon the attention and into the recognition of the least observant, that there is a restless and ceaseless activity to meet, in every variety of form and method, all the numberless wants and demands that society feels, and to which any expression is given; and the exercise of industry, ingenuity, and invention to this end has become so common, and has been so successful, that the most marvelous productions are simply in line with expectancy, and scarcely any longer excite wonder or admiration. While this state of matters obtains in regard to things generally, and while the devices and methods of fifty years ago have been, like the flint-lock gun and the stage coach, put away to make room for more modern and superior contrivances, it yet remains that the vast development of ocean travel in the past half century and the increased water traffic of every kind has been unattended, excepting in rare instances, with any change whatever in the method of launching ships' boats, and with only here and there such changes in detail as leave the vital requisites yet to be found, recognized and put into use. Such a state of things is in these times an anomaly, and confronts us with the question, Why should this be so? This is much more easily asked than correctly and satisfactorily answered, and in a measure the solution of it must be left to the unaided consideration and conviction of each individual. It is, however, impossible to believe that the difficulty lies wholly in the lack, with proper inducements, of ability in contrivance.

It is equally clear that any progress in this matter, any effort to introduce improvements, to be successful must be well devised and practically adapted to conditions, and must be aided by an aroused public feeling. One cause, doubtless, why more has not been done in the attempt to improve has been in the lack of technical knowledge on the part of those with whom has rested the adoption of new propositions, and a consequent want of confidence in any estimate they might make of the value of such propositions, or of the possibility of effecting any amendment. Another cause has probably been that, in the very nature of the case, marine disasters are removed from public observation, and impressions in regard to them usually come from survivors, and these in the worst cases are few or perhaps none. Abundant proof has been had, from time to time, of the power of a ship's boat, successfully launched and well handled, to survive the storm in which the vessel herself foundered; yet how many are the cases which will come to memory of any one who may choose to recall them, of vessels that have left port never to be again heard of. The writer has no wish to be an alarmist, but, in this matter, to be forewarned should assure that we be forearmed. We all know the suddenness with which disasters may occur to any vessel, some of them of a character such as no human care or foresight can foresee, and no human skill can prevent, and to meet these no means of launching boats other than the most prompt and reliable can be of any avail whatever. It is not alone that a ship may strike off a rocky coast, on a dark night, and be under water in ten or fifteen minutes, through faulty and unchecked navigation; such occurrences can be rendered far from likely by better methods and checks, which I am happy to know have been introduced on some of the best steamship lines; but who shall say that any means yet devised will prevent the possibility of collision with an iceberg or a derelict, on a dark night or in a fog?

In case of such an event it is not to indulge in mere hypothesis or speculation to say that, with a vessel proceeding at any ordinary speed, nothing but the most speedy launching of boats would be effectual to save a single life. To say this is not to speculate, but to state the result which might reasonably be expected. In this respect, to have had boats afloat in five minutes would, no doubt, in disasters of the past, have been the means of saving countless hundreds of human lives, where an inability to do this in fifteen minutes, or even ten, has meant blank failure and a calamitous end to faithful and heroic efforts, which in many cases may have left no record, and only blank mystery. If any apology is needed for presenting a subject in this way, to a society which perhaps, in mere ordinary course, is accustomed to give its attention exclusively to matters of economy and mechanics, it may be accepted as sufficient that the writer regards the society as more capable than any other of dealing instructively and effectively with the question; and he hopes by impressing upon the society the need of improvements to enlist its aid to the effecting of them. He has greater expectation from this, and from remarks and suggestions which may be made as the result of reading this paper, than he has from any original devices or suggestions that he may be able to present. As a further excuse for dwelling somewhat on the need of improvements, and of greater attention to the subject of launching ships' boats, the writer feels impelled to state that he has stood four different times on ships' decks when it has been necessary to launch boats to save life, and on none of them was this quickly and effectively carried out. On the last and most disastrous of these occasions, it was most distressing to see 150 men, women, and children waiting through ten to fifteen minutes, each elapsed minute narrowing the limit of life to over two-thirds of that number, only one boat being got clear of the ship, and that one in a damaged condition, efforts faithful, persistent, strenuous, efforts attended in some instances with serious injury to workers, and ceasing only when workers and passengers were submerged.

The question has no doubt occurred ere this to the minds of many of those I am addressing. Wherein is the difficulty? And some of these may say, "I have seen boats put afloat from a ship's deck within three minutes from the time when the order was given." This is quite true where all conditions are favorable, where it is daylight and everything is in plain view, where the ship is neither rolling nor listed to starboard or port, where, perhaps, only one boat has to be launched, and this one handled exclusively by sailors; but the impression gained by any such experience is apt to be misleading, and it has, I feel assured, misled many who have an interest in such matters.

A better conception of this state of things may be had if I should refer to an examination of the appliances for launching on one of the largest transatlantic steamships recently made, in the company of one of the ship's officers. The davits were of the ordinary kind, turning in sockets on the ship's sides, and with the heads usually turned inboard and over the boats, resting in chocks upon the vessel's upper deck; many of the details connected with launching were excellent, and I shall have hereafter to refer to and recommend some of them. The boats were large and heavy, but it was easy to credit the claim made, that, on occasions, one of these had been put into the water in two and a half minutes. When, however, the question was asked, "What could you do if the vessel was rolling or listed?" the answer was, "We know we could not launch them at all." This answer has since been confirmed by other practical and intelligent officers to whom it has been put. The chief difficulty appears to be this, that while it is comparatively easy to turn heavy davits, and to move heavy boats in the direction of a horizontal plane, and while such davits and boats will stay put, and the davits can be stayed by the ordinary guys in the inboard or outboard position when the ship is upright in quiet water, neither movement, staying nor control of this, perhaps two tons weight or more, is practicable when the vessel is rolling or pitching in a seaway, or when she is listed to port or starboard; on the contrary, as I know from experience and actual occurrence, attempts to get the boats over the side at such times are liable to be attended with the loss of life or limb, or by other injury; and the most strenuous efforts made and long continued are apt to be wholly abortive. The crudity and inadequacy of these contrivances would seem to be obvious to any one whose attention is called to them, and indeed the certainty of difficulty, if not of defeat, under any but the most favorable conditions.

Where it is expected that heavy boats will have to be used with any frequency at sea, it is, I think, safe to say that no such means of launching them would be relied on. It would be regarded as a novelty to see a whale ship fitted with davits of this kind. While it is not to be expected that Atlantic liners shall be fitted with whale ship's davits, it appears both interesting and instructive to inquire how far it is practicable to carry ship's boats inside the lines of a ship's sides, and yet at all times outside the davits; and also to inquire if any better means can be used to operate and control the present common form of davit. Before doing this it may be well to mention the chief details of work necessary in launching: removal of the canvas covering, casting off the gripes, throwing down the outer chock (if this be so arranged), casting off the lanyards or tackles of the guys, hoisting the boat clear of its seat, pushing outward the boat and davits and securing the guys, lowering away evenly the boat by the falls, and unhooking the falls and pushing clear of the ship. Every one of these processes is important, and many of them in instances have been improved. In the search for new forms of davits it is questionable if the same identical form will be found equally applicable in all cases; and even if the same form is found to be generally applicable, some modification of detail will be necessary. To my mind the principle of the Mallory davit, patented in 1871 and 1873, has much to recommend it; it is simple and vastly superior to the common form.

It is inexpensive, not bulky, has no need of guys. The boat, though kept inboard, is always outside the davits, and gravity alone will carry the boat outward, ready for the lowering, when the ship is on an even keel or only moderately listed, and when more extremely listed any force used to overcome this is more easily and much more effectively applied. The accompanying illustrations will make the construction and the mode of operation sufficiently clear. A frame made of stout angle iron is extended outward from the top of a house or boat deck, across the width of the gangway of the deck below, and then vertically to that deck, where it terminates and is secured inside the rail; the horizontal part and a small portion of the vertical part of this frame is made double, with a separation and a space of approximately two inches between the two members of the frame. Hinged near to the house on the lower deck, on a level with the foot of the frame, and separated from it by the width of the gangway, is the davit; this extends upward from the hinge, to and beyond the inboard side of the boat, over which the head is bent in the usual manner.

When the boat has to be launched, it is raised by the falls from its seat, the chocks thrown down, and the boat allowed to move outward by means of the fall attached to the back of each davit, and to a distance sufficient for the boat, when lowered in the ordinary or in any other way, to be clear of the ship. This form of davit does not appear to have been adopted or known to the extent that might have been expected. It is a strong and a light device, the strain upon it being only in one direction, and there being no occasion to make it circular in cross-section, being made from flat bar iron. Those I have seen on the newer vessels of the Old Dominion Line (used for boats not of the heaviest kind) being about 5 inches by 1¼ inch in cross-section. There is no uncertainty, in my view, as to the advantages of this davit, and none as to the differences in result which might have been attained had this method of working been in use where it was my painful experience to see others fail.

It is, however, I think, susceptible of adaptations that have not yet been made, and is too open to the criticism that the means to operate it under favorable and also unfavorable conditions are not present, are not all of them fixtures, and always ready for use. The fact that two tackles, one to each davit, have to be stretched across the deck, seen to be clear, and hooked on before the davits are operated, is an objection; and although, in case of rolling or extreme list, these davits would be easier to control than the ordinary ones, this is not enough. To fitly meet such occasions as arise, appliances should be such as by reliable and simple means, not to be defeated by rolling or listing, requiring only manual power and few men, and controllable throughout the process, the boat must be moved out to a position ready for lowering. The operative means to effect this should be a reasonably compact and unobtrusive fixture, always ready for use. Reference to the cuts will show how easily could be arranged, in connection with them, a small shaft upon the upper deck, running in line with the boat and just inside the davits; this shaft could be supported at each end by a compact frame or standard, have winch handles on, and a sprocket wheel near to each end; over this wheel would pass a chain which would also pass over a pulley upon the outer part of the davit frame. The ends of the chain would be connected with the davit on opposite sides, in such a way that the revolution of the sprocket wheel by the handles would move the davits either outward or inward, or hold them at any point desired.

It will be seen how a turn with the bight of the boat falls, over a small drum placed on the shaft, would at the same time carry out the davits and raise the boat from its seat. In such ships as have a shelter deck extending over the width of the gangway of the deck below, davits of the form shown could not be used without the shelter deck, on which the boats rest, having slots cut in them for the movement of the davits outward and inward; the extent of such slots could doubtless be much reduced in such cases by modifying the form and curvature of the davits, and, if need be, by also changing somewhat the detail of the method used for operating them, and this without any departure from the general character of the means used. It does not appear evident, however,

* Paper read before the Society of Naval Architects and Marine Engineers.

that any insuperable difficulty or objection can apply, on account of weakening or impairment of the shelter deck through the presence of such slots, which could be supplied with proper curbs, and which openings the chocks would ordinarily cover. The writer will not pretend to deal exhaustively with this, or, indeed, with any other part of this subject, with the mechanical parts of which he feels that many of the capable minds of this society can deal more effectively than he can.

Any reference to the class of davits which fall outward from the sides of a vessel would be very incomplete which should omit to notice the ingenious and well worked out device of Sir Bradford Leslie, of Falmouth, England. Sir Bradford is a retired engineer of much experience in the East Indies.

His life was placed in jeopardy by shipwreck some years ago, and he has shown that he possesses the requisite technical skill to deal with the detail of his invention in a very thorough manner. For an intimate acquaintance with it I must refer you to the United States patent, May 4, 1897, No. 582,069. The chief novelties of his method are that there are no boat falls, no lowering or hoisting tackles attached to the boats; these are supported from below on cradles situated on the heads of the davits. The davits themselves are lowered vertically in slides down the outside of the ship through the space of a few feet; having passed downward through this space, the heads of both davits, with the boats resting upon them, fall evenly outward and downward, until the boat is deposited on the water at an oar's length or more away from the ship, the davits being allowed to sink a sufficient distance free of the boat. The lowering apparatus consists of a wire rope wound round a drum on the ship's deck, and fitted with a suitable brake. A full description of this contrivance would fill the limits of this paper, and would occupy more time and space than is available.

In regard to the invention, I think it will be conceded that it possesses great originality and thoroughness—that it attains to many desirable ends. If it is thought to be too elaborate or too costly to meet with practical acceptance, it will still, I trust, be deemed a sufficient reason for a reference to it in this paper that its methods are novel and calculated to afford a variety of useful suggestion. While the author of this ingenious invention may feel justly proud of it, my short acquaintance with him has given me a strong impression that he would feel nothing but gratification in having in any way promoted the successful achievement of the end he had in view.

It appears doubtful if any simple and reliable means can be devised for getting boats ready to lower, where the davits have to be rotated, and where the boats have to be moved from a position inside the davits to one outside of them, and this operation, so easy when the deck is level and still, becomes one of extreme difficulty when the vessel is rolling, or when she is inclined; ordinarily the work involves time and effort which ought to be eliminated. The use of a cog-wheel secured to the vertical part of the davit, say immediately over the rail of the vessel, the cogs of which wheel engage with a worm attached to a shaft running horizontally across the rail of the vessel, the said shaft being turned by a handle situated on the periphery of a wheel placed on the inner end of the shaft, seems calculated to give a control over the whole range of the davit's movement not to be had in the ordinary way. The vessel on which I recently crossed the Atlantic had two of her boats fitted with davits operated in this way, and it seems strange that so simple a device is not in more common use.

The patent of James W. McKinnon, March 16, 1897, No. 579,119, has this appliance as one of its features, and has otherwise many ingenious contrivances for raising the boat clear of the chocks, and for the even and steady lowering of it, either from the deck of the vessel or from the boat itself; but I regret that I am not sufficiently familiar with the details of it to attempt a description, and copies of the patent papers do not, as I understand, show the latest development of the invention.

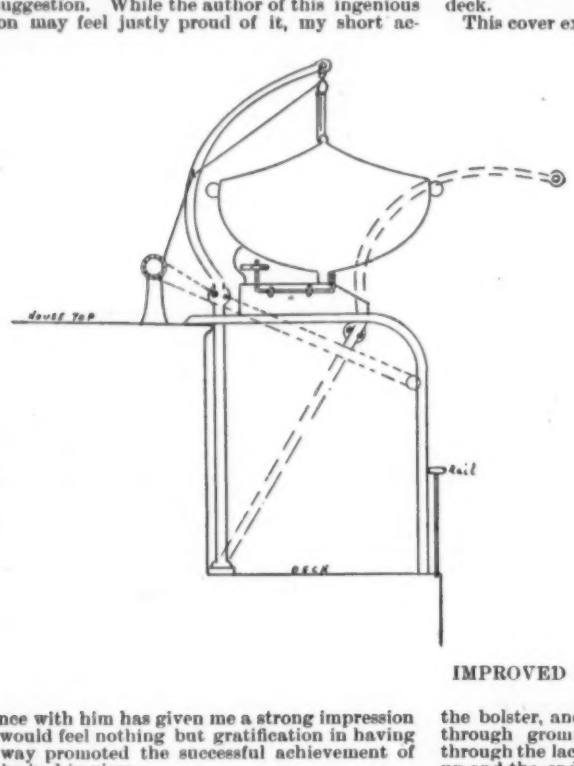
In discussing this subject, I have hitherto occupied myself chiefly with the means for operating the davits themselves, and there is with me no doubt that here, more than anywhere else, is there a confessed need of improvement. I have spoken with many ships' officers, but have yet to meet with one who will say that with the ordinary appliances a ship's boat could readily be launched under conditions of practical difficulty such as have been alluded to. But, while the kind of davits and the mode of operating them is of first importance, every detail and process of launching ships' boats is important and deserving of more attention than it appears to be receiving. Differences in equipment of vessels, often in regard to simple details which scarcely involve the matter of expense, and which do materially affect efficiency in working, suggest as explanation either a want of interest or a need of information, or even, more probably, the need of an institution or of a body of men who, duly qualified, could more than any individual be confidently relied upon to acquaint themselves with these somewhat technical matters, to digest the information received, and to make such statements or recommendations as should appear to be called for in the interest of humanity. With a large measure of authority would come, from such a body, a pronouncement in regard to any davit device observed; also in relation to the respective merits of iron and wooden boats; to the advantage of cork fenders carried in the form of bolsters around a boat and below the gunwale. Chocks and releasing tackle would receive attention, gripes and davit guys would also be commented on, and probably for the guys, if these must continue to be used at all, tackles instead of lanyards would be recommended.

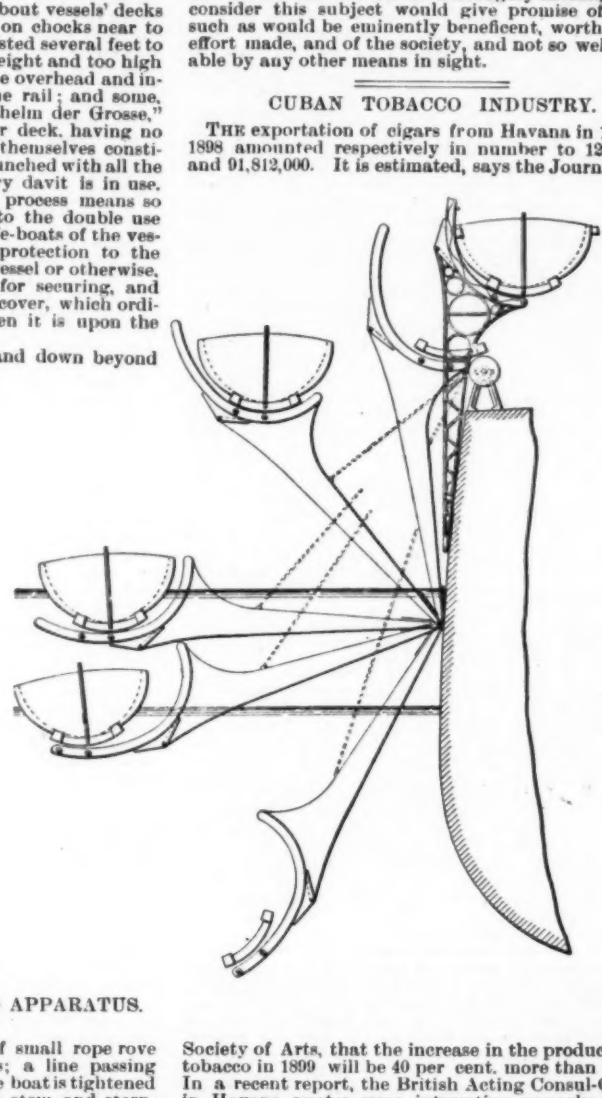
The different situation of boats about vessels' decks is deserving of consideration—some on chocks near to the deck level and needing to be hoisted several feet to pass over a rail; some kept at rail height and too high for passengers to get into them; some overhead and inaccessible until lowered outside the rail; and some, like the boats of the "Kaiser Wilhelm der Grosse," placed upon, and close to, the upper deck, having no rail either inside or outside of them, themselves constituting a bulwark, and ready to be launched with all the facility attainable where the ordinary davit is in use. Where the simplification of every process means so much, attention may here be called to the double use of the cork bolster, put round the life-boats of the vessel mentioned; this is not only a protection to the boat in case of a collision with the vessel or otherwise, but it affords an admirable means for securing, and for instantly detaching, the canvas cover, which ordinarily is fastened over the boat when it is upon the deck.

This cover extends over the sides and down beyond the bolster, and has a loose lacing of small rope rove through grommets upon the edges; a line passing through the lacing along each side the boat is tightened up and the ends toggled together at stem and stern, the effect being to gather the edges of the cover inward under the bolster, and to secure it, and again to instantly release and free it, when this is desired, by slipping the toggle.

The cover in this way is removed intact in very much less time than it could be cut adrift by a sharp knife. Of the various means in use of throwing down the chocks on which the boat rests, or at least of removing the outer ones so that it can be launched, those on the "Kaiser Wilhelm der Grosse" seem adequate and nothing could be more simple. Any pressure from wind or from a sea shipped would be from the weather side, and would bear inward. On the inner side the boat is supported by the two chocks in the customary manner, and is held in firm contact with it by the gripes. It is held from moving outward by an iron rod, carried from inboard outward and horizontally through eye bolts on the face of the lower part—the stationary part—of the chock; this rod is turned up at a right angle, for a few inches at the outer end, in such a way as when operated from the deck at the inner end, where a lever handle is situated, the outer end is turned up outside the keel and the boat's movement is prevented.

The matter of releasing gear is too important to wholly omit mention of in a consideration of this subject; there can, I think, be little doubt that in rough water, with ship and boat in active movement, the handling of boat falls and hooks is attended with both difficulty and danger, even in daylight—it is of course even worse in darkness—whether this be done for the purpose of letting go or hooking on. It is important that the two ends of the boat be lowered evenly, and that the falls be so rove through the blocks that if one end be let go, the other, either by getting foul or being held on to, may not prevent both ends of the boat descending to the water and becoming water-borne. There are many devices for detaching the lower hooks, not all, perhaps, equally free from the risk of fouling or sure of smooth and reliable working. It might be invidious to select one for preference, unless indeed from a more intimate acquaintance with the history of its working than I can claim; the United States government and many merchant vessels have, however, I understand, made considerable use of one of these which appears to me to be a good contrivance, and is well deserving of attention. I will only say, in conclusion, that whatever appliances are used should be kept in good working order. If wooden boats are used, these should not be dried out and leaky, so that they cannot be kept afloat, as has too frequently happened; boat falls should be of good pliable rope that will run easily and freely through the blocks, without choking and without kinking; and for the rest, if the present means for launching boats in times of difficulty and disaster are not improved upon, and if it should ever again be my misfortune to have a ship go down under me, I hope the temperature and distance may admit of my swimming ashore, as otherwise I would rather put my trust in a spar, hatch, or plank or in anything that might float than in the likelihood of getting boats properly afloat in any short period of time. I trust that I may here be permitted to suggest that the appointment of a committee from the members of this association to thoroughly investigate and consider this subject would give promise of results such as would be eminently beneficent, worthy of the effort made, and of the society, and not so well attainable by any other means in sight.





IMPROVED BOAT-LAUNCHING APPARATUS.

CUBAN TOBACCO INDUSTRY.

THE exportation of cigars from Havana in 1897 and 1898 amounted respectively in number to 123,417,000 and 91,812,000. It is estimated, says the Journal of the Society of Arts, that the increase in the production of tobacco in 1899 will be 40 per cent. more than in 1898. In a recent report, the British Acting Consul-General in Havana quotes some interesting remarks by Mr. Gustavo Bock, and states that there can be no doubt that important measures are necessary for the protection of the tobacco industry in Cuba. To insure a planter the sale of his crop at a price in proportion to the cost of production, it is absolutely indispensable that the present regulations prohibiting the importation into the island of all foreign manufactured or unmanufactured tobacco should continue in force, excepting only snuff and chewing tobacco, which have always been imported, and in no way injured Cuban trade or agriculture. Of the many laws and decrees which the Madrid government has issued to favor this colony, none has been wiser than this prohibition of the importation of foreign leaf tobacco, thereby avoiding the importation of a leaf of inferior quality by unscrupulous persons, who after manufacturing the cigar in the way usual in the country, made perhaps with a small portion of Cuban leaf, would export it as a genuine Havana.

This business would prove most profitable to the adulterator, but in time would totally ruin the reputation of Cuban products, both agricultural and industrial, bringing about a decrease in prices which would cause a cessation in the cultivation of tobacco. The production of tobacco in normal times is estimated at 260,000 bales in Pinar del Rio, Vuelta Abajo; 70,000 bales in Havana (called Partido); 130,000 bales in Las Villas, Sta. Clara Remedios; and 100,000 bales in the eastern provinces called Mayari and Gibara: making a total of 560,000 bales. This on an average of 50 kilogrammes per bale is equivalent to 28,000,000 kilogrammes, or 62,173,800 lb. In Vuelta Abajo there is a good deal of uncultivated land, and with permanent peace and a stable government, protection would be insured to capitalists. It is said that this production could easily be increased in the province of Vuelta Abajo alone to 500,000 bales; the provinces of Havana, Las Villas, and the eastern provinces, could increase in

the same proportion. In the manufacture of cigars, cigarettes, and packages of smoking tobacco for home consumption the following number of bales of tobacco are used: Vuelta Abajo 140,000, Partido 10,000, Santa Clara 30,000, and Gibara 40,000; total 220,000 bales. This leaves for export as follows: Vuelta Abajo 120,000 bales, Partido 60,000, Santa Clara 100,000, and Gibara 60,000; total 340,000 bales. At 50 kilogrammes per bale this amounts to 17,000,000 kilogrammes, or 36,956,000 lb. The United States bought and imported from the island 20,000,000 bales in 1895, 26,000,000 in 1896, and 4,400,000 bales in 1897. The universal reputation which this leaf enjoys, owing to the excellence of its quality and the perfection of its manufacture, would, it is said, increase threefold if the industry were promoted. It is to-day the most important industry in the country, and in the provinces of Havana and Pinar del Rio it is the foremost.

With 100,000 cwts., the following has been manufactured: For exportation, 250,000,000 cigars; for home consumption, 50,000,000 cigars; making a total of 300,000,000. In addition to this, the manufacture of cigarettes represents a value of from £600,000 to £800,000 per annum. Even if, under the auspices of peace and by the adoption of proper measures for the future of agriculture and the production of tobacco, a brilliant and promising future is assured, the same cannot be said of its industry and manufacture. The future of the former is promising. The latter, besides being handicapped by excessive competition, has the insurmountable obstacle of being taxed by the treasuries of countries burdened by a heavy national debt.

As a proof of the above, attention is called to the following figures, showing the gradual decrease of the manufacture of tobacco in the island, a decrease which nearly reaches 50 per cent. in eight years. In 1889 the number of cigars imported amounted to 250,000,000; in 1890, 212,000,000; in 1891, 197,000,000; in 1892, 168,000,000; in 1893, 147,000,000; in 1894, 134,000,000; in 1895, 159,000,000; in 1896, 186,000,000; and in 1897, 133,000,000. On the other hand, the exportation of leaf tobacco has increased 50 per cent.; from 197,000 bales exported in 1889 through the port of Havana, the exports in 1895 increased, approximately, to 250,000 bales. The exportation of cigars to the United States shows a considerable falling off during the last few years. In 1889, the number exported to that country was 111,000,000; in 1893, 46,000,000; and in 1897, 34,000,000.

PHOTOGRAPHY IN THE THEATER AND THE STUDIO WITH THE MAGNESIUM LIGHT.

IT was twelve years ago that we spoke for the first time to our readers about the magnesium flash light as applied to photography. Since that time quite an industry has been created for the manufacture of magnesium in powder, of compound powders, and of various apparatus and arrangements designed to facilitate the practice of photography at night.

The idea at once occurred to photographers to utilize the new light at the theater especially, since before it was made known it had been impossible to take a negative of a scene except by a relatively long exposure and with the aid of the electric light. In a few theaters, such as the Chatelet, we found it possible, nevertheless, as long ago as 1887, to obtain good negatives with one or two seconds exposure; but in order to do this it required the obligingness of M. Floury, the director, who allowed us to arrange the light pretty much as we desired. Now, with magnesium, it is possible to operate in all theaters, even in those that use incandescent lamps only; but, still, in order to obtain a good result, one must have a special installation at his disposal. M. P. Boyer, one of our best Parisian professionals, has made a specialty of this kind of work, and there are few pieces that, since the first representation, are not registered scene by scene in his collections. To effect such

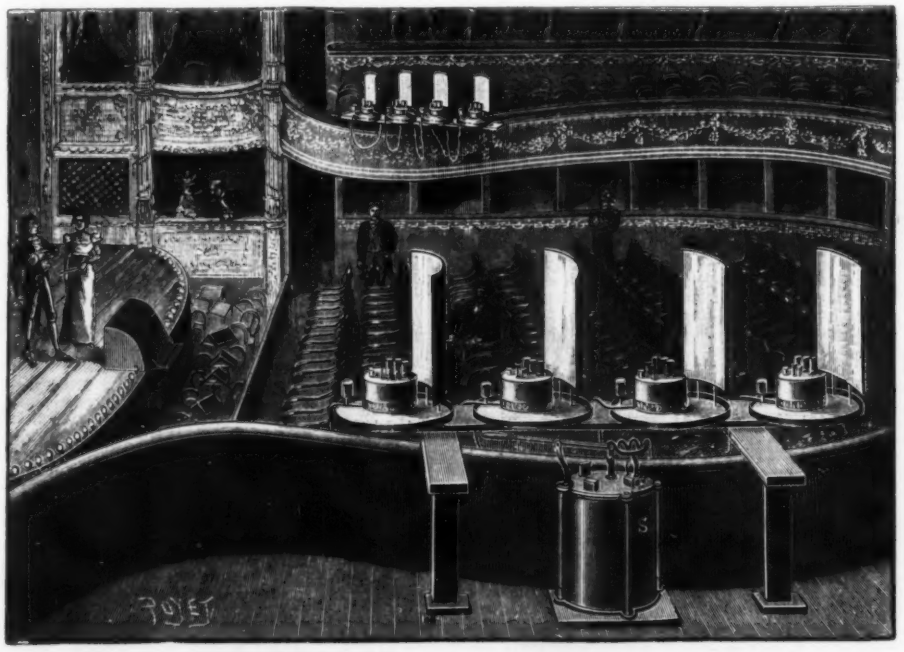


FIG. 1.—ARRANGEMENT EMPLOYED BY M. BOYER FOR PHOTOGRAPHING THEATRICAL REPRESENTATIONS.

work he has at his disposal a collection of lamps and blowing apparatus which he installs on each side of the stage during a general repetition (Fig. 1).

The lamps embrace a peculiar arrangement that permits of prolonging the flash as long as may be desired, through the use, not of a compound powder, but of pure magnesium. They are provided with a reflector and are all connected with a blowing apparatus, *S*, actuated by an assistant at the moment desired. It is thus possible to prolong the exposure as long as circumstances may require it. It must not be forgotten that the walls of the room in which the operation is performed play an important role in photography with magnesium. They serve as a reflector, and the results will be different according as they are of a dark or light color. It is possible to burn an ounce or more of powder in the open air, before a model placed at a few yards distance, without obtaining anything more than a slight indication of an image. We have sometimes burned even an ounce and a half of a powder containing chlorate of potash in a very large hall without any appreciable result, at least as far as the photographic plate was concerned, since the reflector (a wide sheet of nickel plated zinc) had been volatilized. With the arrangement indicated above, such a mischance is not to

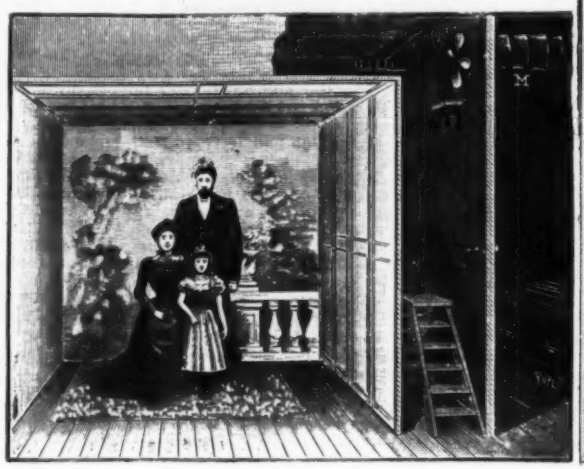


FIG. 2.—BOYER'S PORTABLE STUDIO LIGHTED BY MAGNESIUM.

be feared; and, moreover, we have the excellent results obtained by M. Boyer to prove it.

There are at present few amateurs who have not tried to take a portrait in a room by means of the flash light, and as a general thing, found it rather bad. The reason is, that in order to take a good photograph, it does not always suffice to have light—much light, but also to be able to distribute it properly over the subject; and this is something that the magnesium light permits of doing with difficulty.

To professionals, nevertheless, it is of interest to be able to take portraits in every kind of weather and to prolong the time for sittings until after sunset. In fact, this is often a necessity, not in order to prolong the working hours, but to facilitate the selection of them. A lady, for example, will willingly come to pose in evening toilet at a moment when she is ready to attend a ball, while if she had to dress on purpose in the day time, she would less readily resolve to do so. And as regards actors, how simple it would be were it possible, between two acts, to photograph them as they are, in the foyer of the theater, instead of having them come to the studio with all their costumes and accessories!

Such are the reasons that led M. Boyer to devise the portable studio shown in Fig. 2. This consists of light wooden frames over which is stretched tracing cloth. With these frames are formed the ceiling and two walls of the studio, the back of which consists of some decorative motive or other, while the front is open. All around this room is constructed another and larger one with frames covered with a white opaque fabric. Between the two rooms there is reserved a space about 20 inches in width and entirely closed. It is in this space that is fired the cartridge which produces the flash. The light is diffused in reflecting itself from the walls of the external room and in passing through the tracing cloth that forms the walls of the interior room. The cartridge is generally placed upon one of the corners of the translucent ceiling. In this way is obtained an illumination that greatly resembles that of the studios which receive the light of day. In order that it may be possible for the operator to make a series of negatives without being annoyed by the smoke of the preceding flashes, there is installed in the exterior wall a ventilator, *V*, actuated by an electric motor, and at

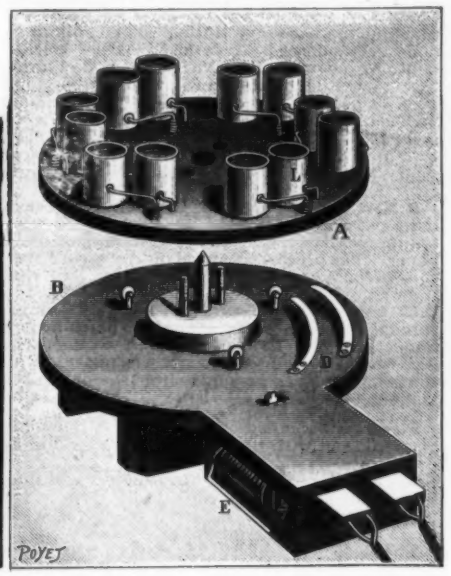


FIG. 3.—ARRANGEMENT FOR BURNING SEVERAL MAGNESIUM CARTRIDGES IN SUCCESSION.

which ends a cloth sleeve, *M*, coming from a window or chimney in the room in which the operating is done.

Since M. Boyer often operates at the theater, where he has electricity at hand, he utilizes this agent not only for actuating the ventilator, but also for maneuvering the cartridge apparatus. The cartridges, *L*, are arranged upon a disk, *A* (Fig. 3), which is placed upon a plate, *B*, that is capable of revolving freely around a central axis.

A very simple mechanical arrangement controlled by an electro-magnet, *E*, permits of causing the disk, *A*, to rotate a certain distance every time a current is sent into the electromagnet. At every movement, a cartridge stops at *D*, above two springs which are connected with the electric wiring. The bottom of the cartridge is so arranged that a wire traverses the powder and ends at the springs, *D*, when the cartridge is in place. It then suffices to push a button in order to send a current into the wire to produce a flash. If one flash is not sufficient, a second one may be obtained by pushing another button. Besides, in order to permit of introducing the plate, focusing and softening the shadows, a row of incandescent lamps is arranged behind the translucent wall on the side opposite that at which the flash is produced. With these ingenious arrangements, we have seen M. Boyer take a score of negatives of actors during the course of a play. The very light outfit is carried and installed with great ease, and the results obtained are as good as if the subject had posed in a studio that had at its disposal all the usual resources of plays of light.—G. Mareschal, in La Nature.

The November issue of the Journal of the Chemical Society contains the following particulars of a research published by Herr H. Scholl in the Annalen der Physik und Chemie. If a silvered glass is exposed to iodine vapor, it becomes covered with a clear deposit of silver iodide, which, on exposure to light, becomes cloudy. The author shows that this cloudiness is not due to any chemical change, but to a mechanical alteration of the illuminated layer, and the change further requires the catalytic action of some oxidizing agent, such as oxygen or iodine. If the silver iodide has an underlayer of silver, chemical action ensues, and the metal becomes converted into iodide with reduction of the surface layers, this action being also accelerated by the catalytic action of the oxygen of the air. The capability of development of exposed Daguerreotype plates is due to the change, and to the presence, in the surface layers, of the reduced silver. It extends also through the whole thickness, and is throughout proportional to the light intensity at the surface. A layer of silver iodide was deposited between two platinized glass plates and connected electrically with a galvanometer. When this was exposed to light, an E. M. F. was produced, the direction of which indicated a migration of iodine in the direction of the light rays.

A recent British consular report says that the ruby and sapphire mines at Pailin, in the Battambong Province, are held by the Siam Exploring Company, Limited, one of the affiliated companies of the Siam Company, Limited. The mines are worked entirely by Shans and Laos, who take out digging licenses from the company, and are then allowed to dispose of the stones themselves. At the beginning of the present year the people were complaining of the poor prices their stones were fetching in Europe and Calcutta; they have since improved somewhat. It is understood that the company has recently entered into an arrangement in London for the introduction of a steam shovel.—Engineering and Mining Journal.

TRADE NOTES AND RECEIPTS.

To Transfer Albumen Picture upon Wood.—According to the Zeitschrift für Drechsler, this is accomplished by coating the respective dried place with a thin layer of copal varnish. Now lay the toned, fixed and washed, albumen picture, while still wet, upon the varnished surface, face down, and press it down firmly. After four hours moisten the back of the picture with a damp sponge and draw off the paper. The picture layer remains, adhering to the under-surface. For protection, it is provided, after drying, with a coating of varnish.

Varnish for Restaurant Chairs.—Prepare a ground of one part of good white lead and one part of yellow lead and the necessary tinting colors ground in good non-viscous linseed oil varnish. Grind thickly and dilute with equal parts of varnish and oil of turpentine. For drier, litharge and burnt vitriol, ground finely in oil of turpentine, is recommended. This priming having been applied as lean as possible, and in a covering layer and dried, grain with vinegar paint and varnish with pure Zanzibar copal varnish, putting the articles to dry well for eight days.—Deutsche Malerzeitung.

A New Copying Process by Means of Tannin has been patented in France by Jules Erydmane, using tannin for the superficial impregnation of parchment paper. The process is carried out by laying the paper thus prepared with the tannin-impregnated side upon the writing in copy ink, moisten it from the back, so that only little moisture reaches the tannin layer through the almost impermeable parchment paper. Same then takes a superficial impression of the writing, which is legible through the paper. It is said that fifty copies can be made from the original in this manner.—Technische Berichte.

Fireproof Paint in Powder Form.—Mix soluble soda-glass solution with zinc chloride solution and dry the precipitate.

Mix 50 parts of this deposit with 5 parts of zinc oxide, 20 parts of ammonium sulphate, 15 parts of sal ammoniac and 10 parts of an earth color—for white, zinc oxide is used—and powder it all finely.

The respective objects are coated with waterglass and next closely sprinkled with the powder. Same is swept off after a while and another application of waterglass is made.—Neueste Erfindungen und Erfahrungen.

Varnishing Trays and Other Tin Ware.—The ground is prepared, says Deutsche Malerzeitung, by adding to the white lead, the tinting colors ground in good rubbing varnish and half oil of turpentine. For drier an admixture of "terebine" is recommended. With this lean and dull paint, coat the tins two or three times and blend. Next, grain with water or vinegar glaze, and varnish with pure Zanzibar copal varnish, or finest amber table-top varnish. There are other tried methods for varnishing tin, which are applicable for new goods, manufactured in large quantities, while they are less advantageous for the restoration of old repeatedly used articles.

Paste for Labels.—The receipt for a paste for damp cellars, which excels by its intensive adhesive qualities, as well as great durability, is as follows, according to Reuthehler: Soak 25·0 of cologne glue over night in 100 c. cm. of strong wine vinegar, add 50·0 of wheat starch stirred with cold water, and boil the whole for a few minutes, until the proper consistency is attained. Finally add 20·0 of Venetian turpentine, mix well and pour out into pots. The paste is used cold or preferably slightly warmed, otherwise it will strike through. For removing the labels, the bottle should be laid in water for about one hour.—Süddeutsche Apotheker Zeitung.

To Render Corks Impermeable.—For the purpose of making corks as impervious as possible, while at the same time keeping them elastic, F. H. Wundram, of Berlin, recommends to saturate them with caoutchouc solution. Dissolve caoutchouc in benzine in the ratio of 1 gramme of caoutchouc to 19 grammes of benzine. Into this liquid lay the corks to be impregnated and subject them to a pressure of 10 to 12 atmospheres by means of a force pump, so that the liquid can thoroughly enter. The corks thus treated must next be exposed to a strong draught of air until all trace of benzine has entirely evaporated and no more smell is noticeable. The process is patented in Germany.—Der Seifenfabrikant.

Coloring Ceresine Candles for the Christmas Tree.—For coloring these candles only dye stuffs soluble in oil can be employed. Blue: 23-24 lavender blue, pale or dark, 100–120 grammes per 50 kilos of ceresine. Violet: 26 fast violet R, 150 grammes per 50 kilos of ceresine. Silver gray: 29 silver gray, 150 grammes per 50 kilos of ceresine. Yellow and orange: 30 wax yellow, medium, 200 grammes per 50 kilos of ceresine; 61 old gold, 200 grammes per 50 kilos of ceresine. Pink and red: 27 peach-pink or 29 chamois, about 100 grammes per 50 kilos of ceresine. Green: 16–17 brilliant green, 33 May green, 41 May green, 200–250 grammes per 50 kilos of ceresine. The above named colors should be ground in oil and the ceresine tinted with them afterward.—Farben Zeitung.

Glazing on Size Colors.—The essential condition is a well sized foundation. For the glazing paint, size is likewise used as binder, but a little dissolved soap is still added, of about the strength as it is employed for coating ceilings. Not only good veining can be done with this, but a better effect can be produced in executing pieces which are to appear in relief, such as cartouches, masks, knobs, etc., than with the ordinary means. A skillful grainer may also impart to the work the pleasant luster of natural wood. The same glazing method, continues Deutsche Malerzeitung, is applicable to colored paintings. If the glazing colors are prepared with wax dissolved in French turpentine, one may likewise glaze with them on a size paint ground. Glazing tube oil colors thinned with turpentine and siccative, are also useful for this purpose. For the shadows, asphalt and Van Dyke brown are recommended, while the contour may be painted with size paint.

MISCELLANEOUS NOTES.

We have already referred to wireless telegraphy for use on Mont Blanc. Experiments have now been tried in sending messages between Chamonix and the top of Mont Blanc. The distance between the stations was 7½ miles and the difference in altitude was 3,350 meters. The experiments were carried out by J. and L. Lecarme. The transmitting mast wire was 82 feet long and was mounted at an inclination of 30° to the ground. Clouds did not interfere with the signals, though atmospheric electricity did interfere with the receiver, but not so as to spoil the messages. The greatest obstacle was the three-phase electric-lighting system of Chamonix, which made telegraphy impossible at night. The stations were visible to each other and the wireless telegraphic messages could be verified by optical means.

Plans are now being perfected by the American Pulley Company, of Philadelphia, for a hydraulic press for the manufacture of their wrought steel pulleys in larger sizes than they have heretofore been made. In design the press will be somewhat similar to the one fully described in The Iron Age, January 6, 1898, which has been used in the manufacture of pulleys up to 24 inches in diameter by 12 inches face. The new machine will turn out pulleys up to 42 inches diameter by 18 inches face, and will have to handle solid steel from ¼ to ⅜ inch thick in the spider or arms, where the greatest thickness of metal occurs. The designs will be ready for estimating upon in about ten days. The new works of the company are rapidly nearing completion, and it is expected that they will be occupied about the first of the year. Some idea of their size may be had from the fact that the roof surface amounts to 50,000 square feet.

A British consular report says that the Kabin gold mines in Siam are being energetically developed, and the erection of a new twenty-stamp mill was completed during July. The local representatives of the company consider that the prospects are good. Crushings have been carried on for the past two years with part of the old machinery brought out over twenty years ago by the Siamese government, and the new mill has largely increased the output. The mine is the property of the Société des Mines de Kabin, a French company, having its head office in Paris, but the Siam Company, Limited, is understood to have a large interest in it, and to have sole control of the management. Some twenty Cornish miners and several Scotch engineers are employed, the manager is English, and an English firm represents the company in Bangkok. The Wattana gold mine belongs to a purely French company, and it is understood that its operations have been so far on an extremely small scale. Not much is known about it, however.—Engineering and Mining Journal.

Magnalium, says The Electrical Review, London, is the name of a new alloy of aluminum and magnesium, discovered by Dr. L. Mach, which is said to possess valuable properties. The addition of magnesium in quantity not exceeding thirty, and not less than ten, parts by weight to one hundred parts by weight of aluminum, imparts to the latter metal properties which in the pure condition it does not possess, without raising its specific gravity (2·64), on the contrary, slightly lowering it, since the specific gravity of magnesium (1·74) is even less than that of aluminum. The addition of magnesium produces an alloy which is harder, and is easier and cleaner to work than pure aluminum. Turning produces a surface as bright as a mirror, and shining like silver, the metal coming off in long spiral turnings. The alloy files clean and regular; without tearing, or choking the file, as aluminum does. Deep and sharp screw threads can be cut on it, and very clean holes can be bored out. The color of the metal resembles silver more than aluminum, and it takes a high polish. The hardness and strength of the alloy are considerable; the hardness can be varied by varying the proportions of aluminum. An addition of heavy metals is not only unnecessary, but is positively injurious, since this deteriorates its working properties and increases its specific gravity. Previous attempts to make useful alloys of aluminum and magnesium are said to have failed, owing to the aluminum not being pure. This point is of great importance, and aluminum made by an electrolytic process must be used.

Three or four centuries before our era, Æneas invented several systems of signaling. In particular, he devised the first synchronic apparatus. At each station was installed a great vessel of uniform capacity, having in its side a hole of the same size for each vessel. At the surface of the liquid contained in the vessel was a float in which was fixed an upright rod divided into equal parts, each of which corresponded to one of the phrases to be telegraphed. The attendant at each station had a torch. When he first raised his torch he uncorked the hole in his vessel, allowing the water to escape and the float to sink; the attendant at the second station did the same, and this was repeated from station to station. When the division of the rod corresponding to the message to be sent had fallen to the level of the edge of the vessel, the first attendant lowered his torch and replaced the cork; the others, imitating his action, could then read off on their rods the particular message sent by the first. . . . In all such methods as these the messages were limited to words or phrases agreed upon beforehand. In the second century B. C., Cleomenes invented a method of doing away with this inconvenience by combining luminous signals so as to form a code. Each station was furnished with several huge fire-vessels corresponding each to a group of letters of the alphabet. The one that was exposed so that it could be seen from the next station, while the others were hidden, indicated the group including the letter to be transmitted, which letter was then shown more closely by lanterns. Polybius improved this by dividing the alphabet into five groups, four or five letters and one of four. These were telegraphed by torches moved in given directions. For instance, three torches at the left of the station meant the third group, then two at the right meant the second letter of this group.—New York Tribune.

SELECTED FORMULÆ.

Substitute for Poultices.—M. J. Wilbert suggests the following formula for a substitute for poultices: Kaolin, 1,000; glycerin, 1,000; boric acid, 100; oils of peppermint and wintergreen, each 1: oil of eucalyptus, 1. The kaolin is passed through a No. 60 sieve to free it from impurities, and heated to 100° C. for an hour or more to sterilize it; then add the glycerin and continue the heat for thirty or forty minutes, stirring the mass occasionally with a spatula, until a smooth, creamy mass is obtained. Remove the source of heat, and, when the mass is nearly cool, add the boric acid and the oils; mix thoroughly, and preserve in tin or glass boxes, which are sufficiently tight to prevent the absorption of moisture from the atmosphere. Similar preparations have been sold in America under the names "Antiphlogistine" and "Antithermaline."—Am. Journ. Pharm., 71, 478.

Harmless Colors for Confectionery, Cakes, Sirups, etc.—The following are excellent and entirely innocent coloring agents for the purposes named:

RED.

Cochineal sirup, prepared as follows:

1. Cochineal in coarse powder	6	parts.
Potassium carbonate	2	"
Distilled water	15	"
Alcohol	12	"
Simple sirup enough to make	500	"

Rub up the potassium carbonate and the cochineal together, adding the water and alcohol little by little under constant trituration. Set aside over night, then add the sirup and filter.

2. Carmine No. 40	1	part.
Stronger ammonia water	4	"
Distilled water sufficient to make	24	"

Rub up the carmine in the ammonia water, and to the solution add the water. If on standing the carmine shows a tendency to separate out, a drop or two of ammonia will correct the trouble. This statement should be put on the label of the bottle, as the volatile ammonia soon escapes, even in stoppered vials.

PINK.

1. Carmine	1	part.
Liquor potassæ	6	"
Rose water enough to make	48	"

Mix. Should the color be too high, dilute with water until the requisite tint is acquired.

2. Soak red apple parings in California brandy. The addition of rose leaves makes an exquisite flavoring as well as coloring agent.

ORANGE.

Tincture of red sandalwood, 1 part; ethereal tincture of orlean, q. s. Add the tincture of orlean to the sandalwood tincture until the desired shade of orange is obtained.

A red added to any of the yellows gives an orange color.—National Druggist.

Eggs of Pharaoh's Serpents.—This toy as originally made consisted of pellets of a very poisonous mercurial compound, which gave off dangerous fumes when heated. The "eggs" may be made of comparatively safe material by the following formula:

Potassium bichromate	2 parts.
Potassium nitrate	1 "
White sugar	2 "

Powder each ingredient separately, mix, and press into small paper cones. These must be kept from light and moisture.

Of course, neither this nor other chemical toys containing substances in the slightest degree harmful if swallowed should be placed in the hands of children not old enough to fully understand the danger of eating or even tasting unknown things.

Stove Polish.—As the season is again here that brings a demand for stove polishes, it may be useful to bring forward some information about their preparation.

Graphite (often misnamed black-lead) is the foundation ingredient in a stove polish. Lampblack is frequently added to deepen the color, but the latter form of carbon is of course more readily burned off than the former.

The powder variety of stove polish is merely purified and ground graphite, with or without the addition of lampblack, which is applied to the stove by being first mixed with a little water.

The paste is made by the addition of glycerine or paraffin oil to the powder.

The following formula gives a liquid stove blacking:

Graphite in fine powder	1 pound.
Lampblack	1 ounce.
Rosin	4 ounces.
Turpentine	1 gallon.

This form may be esteemed a convenience by some, but the rosin will, of course, give rise to some disagreeable odor on first heating the stove, after the liquid is applied.

The mixture must be kept well shaken while in use, and must not be applied when there is a fire or light near on account of the inflammability of the vapor.

The solid cakes of polish are said to be made by subjecting the powdered graphite, mixed with spirit of turpentine, to great pressure. It has to be reduced to powder and mixed with water before being applied.

Any of them has to be well rubbed with a brush after application to give a handsome finish.—Druggists' Circular.

Florida Water.—

1. Oil of bergamot	2·0	grammes.
Oil of lavender	2·0	"
Oil of lemon	2·0	"
Oil of orange flower	0·05	"
Oil of rose	0·01	"
Alcohol, 95 per cent	1,000·0	"
Orange flower water, Rose water, of each	450·0	"
2. Oil of lemon	5·0	"
Oil of bergamot	3·0	"
Oil of lavender	2·0	"
Oil of cloves	5·0	drops.
Oil of orange flower	10·0	"
Alcohol	890·0	grammes.
Distilled water	100·0	"

—Pharmaceutical Era.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Nettle Fiber in Germany.—Consul Sawter, of Glauchau, under date of September 26, 1899, says:

Nettle fiber has of late come greatly into favor in the manufacture of fine yarns and tissues. In Germany, there are factories which use these fibers both in spinning and also for ulterior purposes. In nettle-spinning alone, over 10,000 spindles and some hundred workmen are employed. The raw material is imported almost exclusively from China, whence 3,000 to 4,000 double cwts. (661,500 to 802,000 pounds) are annually sent to Germany. Nettle fiber produces one of the finest tissues obtainable from any known kind of vegetable fiber. In view of the importance which this seems likely to attain in connection with the weaving industries, it is intended to introduce the cultivation of nettles, if possible, into the Kameroons. The idea is to prepare the products of this experimental culture at the place where they are obtained, and test them in German factories. Should favorable results follow from these experiments, it is intended to organize nettle-growing enterprises on an extensive scale.

Precautions against Tuberculosis.—In accordance with instructions from the Department, Consul Covert, of Lyons, under date of September 13, 1899, transmits the following translation of the report of the League for the Prevention of Tuberculosis for 1898:

For every six persons in this country, at least one dies of consumption. Of the 850,000 deaths that occur every year in France, over 140,000 are caused by pulmonary tuberculosis or phthisis, and this number, instead of decreasing, goes on augmenting every year. Hardly a family but pays to it a sad tribute. No disease, no scourge, can be compared to tuberculosis, so far as the number of the victims is concerned. All epidemics and contagious diseases combined—typhoid, varioloid, scarlatina, measles, diphtheria, cholera, etc.—do not cause half as many deaths.

We would then be acting like madmen if, knowing the means to diminish the ravages of this most terrible of our enemies, we did not as physicians make them known to the public; and if, knowing that tuberculosis may be transmitted from man to man and from animals to men, we knew means by which such transmission might be prevented or limited, we would be grossly culpable if we failed to make known such preventive measures. Science is to-day possessed of a knowledge of the means of diminishing the ravages of tuberculosis.

It is known that in the immense majority of cases a consumptive does not possess the germs of that disease at birth.

It is known, thanks to Villemin, that the greater number of the 140,000 consumptives who die yearly in France have caught the disease either in breathing the air charged with the germs of tuberculosis or, less often, by eating food which may accidentally contain those germs.

It is known that these germs of tuberculosis (bacillus de Koch) are spread by consumptives around them, each patient becoming, by his expectoration, a center of emission of these infected particles.

It is known that by certain simple precautions it is possible to destroy the greater part of these germs that are scattered through the atmosphere, and consequently, to prevent the greater number of cases of consumption.

It is known that contact with the consumptive is in no sense dangerous; that neither his person nor his breath is poisonous; that one can talk with him for hours together, inhale his breath, live with him, sleep with him, give him the most constant care and attention, without running any serious risk if certain precautions are taken, the principal one being to clean up his expectoration and not delay destroying it until it has become dry and been taken up in the atmosphere.

It is known that by extreme cleanliness we not only prevent the patient from becoming dangerous to others, but that we do him a great service, for he is prevented from reinfecting himself and from destroying the beneficial effects of treatment which would often be successful if these precautions were rigorously enforced.

Therefore, the congress for the study of tuberculosis, where all the specialists of that disease were assembled, has issued a set of instructions to teach the public how to prevent the spread of the disease.

TUBERCULOSIS INSTRUCTIONS.

Tuberculosis is, of all diseases, that which has most victims. In large cities they make up from one-fourth to one-seventh of the mortality.

To explain this high figure, it must be understood that pulmonary phthisis is not the only manifestation of tuberculosis, as is erroneously believed. In fact, many cases of bronchial troubles, of pleurisy, of meningitis, of peritonitis, enteritis, of osseous and joint lesions, cold abscesses, etc., are of the same nature.

Tuberculosis is an infectious, parasitic disease, caused by microbes; but it can be caught by a healthy person from a patient only under special conditions, which we will state.

Besides hereditary transmission, the tuberculosis microbe enters the human organism by the air in breathing, through the digestive organs in eating, through the skin by stings, scratches, sores, wounds, ulcers, etc.

The most frequent and the most dreadful source of contagion lies in the expectoration of consumptive patients. Almost harmless while in a liquid condition, it becomes dangerous when reduced to powder. It assumes that form often when spat upon the ground, the floor, or upon a wall; when it falls on clothing, bedclothes or sheets, curtains, handkerchiefs, napkins, etc.

When dried and in powder, it is stirred by the dust cloth, the broom, brush, or carpet beater. This dust suspended in the air enters the respiratory organs, falls upon portions of the body, upon objects used in cooking, plates, and dishes, and thus becomes a permanent danger to persons sojourning in the contaminated atmosphere. The germs of contagion also exist in the evacuations of the patients, produced either by saliva swallowed, or by intestinal lesions so common in such diseases.

It is indispensable therefore—

To take the most careful precautions regarding the expectoration of consumptives. It should always be ejected into porcelain or glass spittoons, containing a certain quantity of liquid; and not in such matter as sawdust, bran, sand, or ashes. The handkerchief upon which the patient should wipe his lips only, and upon which he should never spit, should be renewed every day.

The contents of the spittoons should be mixed with sawdust or some other combustible and burned, or at least emptied into the water closet. If emptied into a yard, they may tuberculize fowls or allow microbes to spread through the air. No known disinfectant is powerful enough to rapidly destroy the tuberculous microbes [contained in saliva; therefore, the contents of spittoons should be destroyed by boiling or thrown into closets. At the same time, there should be poured into the closets a solution of chloride of lime. It would be safer to mix the saliva with saw dust and burn it.

Spittoons should be used, not only in hospitals and private houses, but also in depots, barracks, and all places for public meetings.

These precautions should be taken in reference to all diseases that occasion much expectoration, because pneumonia, inflammation of the chest, congestion of the lungs, measles, whooping cough, catarrh, certain forms of bronchitis, laryngitis, etc., may be communicated by saliva dried and converted into dust.

Clothes soiled by a consumptive patient should be left some time in boiling water before being washed.

Avoid sleeping in a room with a consumptive patient, and remain in it as little as possible, unless the above-mentioned precautions are taken in regard to saliva.

Rooms in hotels, watering places, etc., occupied by consumptives should be so furnished and carpeted that disinfection can be readily accomplished after the departure of a patient.

After the death of a consumptive, the place inhabited by him should be carefully disinfected and thoroughly aired. New tenants should see that these precautions are taken.

After the death of a consumptive, all his clothing and bed linen should be well washed before being used and the room thoroughly disinfected by sulphur vapor and washed with chloride-of-lime water.

In private as well as public houses, carriages, omnibuses, hotels, theaters, etc., sweeping ought to be replaced by washing with a cloth wet with some antiseptic solution.

The parasite of this disease may also be found in beef (above all, cow beef), poultry, rabbits, and milk. The latter should be boiled, or, better still, sterilized. Milk is sterilized by placing the vessel containing it in a tin pail full of water and letting it boil forty-five minutes. The habit of drinking blood at slaughterhouses is dangerous and without any salutary results.

Some persons have a tendency to consumption and should be especially careful; for instance, those whose relatives have died from consumption or who are feeble from privations. The abuse of alcoholic liquors is particularly favorable to consumption. Over 2,000 infants under two years of age die annually of consumption in Paris.

This disease is curable, where it has not advanced too far, for those who are willing to submit to long months and sometimes years of treatment and repose in special sanitariums.

Water Famine in Maracaibo.—Consul Plumacher writes from Maracaibo, August 22, 1899, in regard to the scarcity of water. No rain, it appears, has fallen for months, and the situation is becoming serious. The state of Zulia, he adds, is not a manufacturing state, but relies entirely upon agriculture and cattle raising. The price of every article of food has risen 20 per cent. during the last three weeks; meat alone is comparatively cheap, as the people have to kill their cattle. Everything is suffering for water except the cocoanut trees, which are flourishing. This industry, says the consul, is undoubtedly profitable, as these trees seem to grow best without rain.

Quay at St. Malo.—Under date of September 28, 1899, Consul Thackara, of Havre, reports that St. Malo is about to expend 1,000,000 francs ($193,000) in building quays along one of its basins. As the quays are to be built of stone, he adds, it is not likely that Americans could compete with the French, who know just what stone is required, where to procure it, the best ways of transporting it, the prices to be paid, etc.

Petroleum and Naphtha in Canada.—Under date of September 11, 1899, Consul McCullough sends from St. Stephen copy of instructions issued to collectors of customs in Canada relating to the importation, inspection, and storage of petroleum and naphtha, containing the following provisions:

Petroleum and naphtha (not in bulk in tank ships, vessels, or barges) may be imported in tank cars, barrels, or other packages at any port or outport of entry in Canada.

Petroleum which, when tested by the method set forth in the petroleum inspection act, will not flash at a lower temperature than 85° F., may be imported in tank ships at such customs ports only as are from time to time designated by the Governor-General in council.

Petroleum may be put up and sold without inspection marks and irrespective of the size of packages, and the inspection fees have been abolished.

Packages containing naphtha are to be branded as such, and they are to be painted red, while packages containing petroleum may be painted any color other than that provided for packages containing naphtha.

All petroleum and naphtha imported into Canada, whether in tank cars, tank ships, barrels, or other packages, shall be inspected as required by the act before customs entry.

Frozen Russian Pork in Germany.—The following, dated Frankfort, October 19, 1899, has been received from Consul-General Guenther:

At Mainz, Germany, experiments have just been made with frozen Russian pork by the several regiments of infantry stationed there. About a ton of this pork, which had arrived in a solidly frozen state, was used for dinner, but the result of the experiments, according to the reports published in German papers, was not satisfactory.

The meat, it is said, emitted an unpleasant smell while being boiled, and after being boiled for fifteen minutes became like a hard paste. The taste also left much to be desired.

Iron Production in Europe and America.—The production of raw iron in Germany, England, and the United States is interesting the industrial centers of this empire, says Consul J. C. Monaghan, of Chemnitz. The most important industry of Germany, after coal mining, is iron working. While, for certain purposes, iron comes in from Scandinavia, England, and other foreign parts, most of that used in this empire is dug from its own mines.

PRODUCTION OF RAW IRON.

Year.	Germany. Tons.	England. Tons.	United States. Tons.
1872	1,988	6,850	2,589
1876	1,846	6,661	1,899
1886	3,529	7,122	5,774
1891	4,641	7,523	8,412
1896	6,373	8,798	8,761
1897	6,882	8,937	9,807
1898	7,216	...	11,962

These figures furnish an interesting array of facts. They tell a tale of prosperity and progress in Germany and the United States unprecedented in the history of industrial effort. England, that formerly led both the other countries, is now far behind the United States, and is having all she can do to hold her own against Germany.

"It is well known," says a German writer, "that American methods are so highly developed as to put the iron people there in a position to compete with England and Germany, not only in international markets, but in London, Liverpool, Glasgow, Belfast, Hamburg, and Berlin."

T'ung Oil in China.—Consul-General Goodnow transmits from Shanghai, August 25, 1899, a letter from Mr. Stephen P. Barchet, interpreter for the consulate-general, to a Chicago firm,* from which the following is taken:

T'ung oil is extracted from the seed of the paint tree (Dryandra cordasa), which is extensively cultivated in the Yangtze Valley, also in Chekiang Province. This interesting tree would probably grow in the Southern States and in California and could be cultivated with profit. The seeds of the paint tree are poisonous, and the oil is used occasionally for poisoning rats, also to produce vomiting in would-be opium suicides, though for the latter purpose it is neither as safe nor as effective as zinc sulphate or the stomach pump. The chief use of t'ung oil is as a standard paint, and as such it is in great demand by the natives. When boiled, it makes one of the best drying oils; it is also extensively used in varnishing with the famous Ningpo varnish "t'si"—i.e., the dried sap of the varnish tree (Rhus vernicifera), a good coating of which will stand considerable heat without leaving a mark and will last for years. The various shades for coloring are produced by animal, vegetable, and mineral substances. Pig's blood is the favorite for a first coating in varnishing. To give body and luster to paint, they mix with the oil finely powdered galena and other ores. Current wholesale quotations for t'ung oil are 8 taels per picul (133 pounds) or 5 to 6 cents (gold) per catty (1⅓ pounds). Freight charges to San Francisco are just now $2.50 in United States currency per ton, but oils have to be shipped as deck packages, for which fancy prices are paid—$6 gold per ton to San Francisco.

Soda Nitrate in Chile.—In a letter to a Massachusetts firm,† Consul Merriam, of Iquique, under date of August 8, 1899, writes:

The cost of production of nitrate varies greatly in the different establishments, depending upon the abundance and quality of the "caliche," or crude nitrate, distance from port, price of coal, etc. Moreover, the manufacturers are not disposed to declare the cost of production, considering this to be one of the secrets of the trade. Railroad transportation rates to the coast are 6d. (12 cents) per Spanish quintal of 100 pounds for 40 miles or more, with a proportionate reduction for distances under 40 miles. On and after January 1, 1900, the rate will be 4½d. (9 cents). The average rate of ocean freights for nitrate from January to June of the present year has been 27s. 2d. ($6.61) to Europe and the United States. I give below figures showing the exportation of nitrate of soda from the ports of Iquique, Pisagua, Junin, Calesa, Buena, Antofagasta, Trocopilla, and Taltal:

	Long tons.
1896	1,091,681
1897	1,063,349
1898	1,272,121
First six months of 1899	557,327

Grain and Grass Crops of Thuringia.—Consul Hughes, of Coburg, under date of October 18, 1899, reports that the grain and grass crops of Thuringia in the past season have been large and of good quality. As many as three, and in some favored spots four, crops of clover and grass have been cut off the same land, the red-top clover being the best the consul says he has seen in that part of Germany. He warns exporters not to ship hay, etc., on commission as the present supply is large.

* To whom the original has been sent.

† The original has been forwarded.

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No. 589. November 27.—Coal Trade in Belgium—Japanese Gold Standard and American Trade.

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The Reports marked with an asterisk (*) will be published in the SCIENTIFIC AMERICAN SUPPLEMENT. Interested parties can obtain the other Reports by application to Bureau of Foreign Commerce, Department of State, Washington, D. C., and we suggest immediate application before the supply is exhausted.

RECENT EXCAVATIONS IN ANCIENT BABYLON.

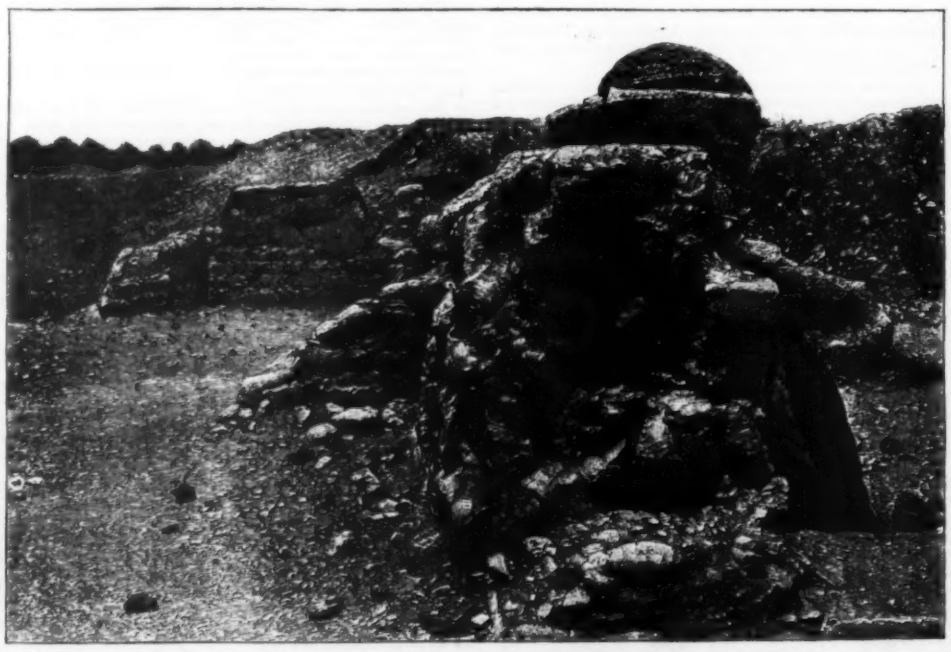
THE discoveries of French, English, and American archæologists in the ruins of ancient Assyrian cities on the banks of the Euphrates and Tigris have aroused German orientalists from their lethargy, says Die Illustrite Zeitung, and induced them to send out an expedition under the leadership of Robert Koldewey. The first important excavations ever undertaken were made in 1842 by the French consul Botta, in the ruins of the palace-city of Sargon, the conqueror of Samaria. Botta's success spurred on Sir Henry Layard to excavate, in conjunction with Rassam, the mound of Kujundshik opposite Mosul and to unearth the magnificent structures of ancient Nineveh, the palaces of Sennacherib and Sardanapalus. After having finished with the royal palaces of Assyria, the explorers began work on the Babylonian palaces, temples, and towers, proceeding from the sun temples of Sippar and Nippur of the city of Bel down to the southern Babylonian mound of Tello. The discovery of all these palaces, dating from the time of the Assyrian and Babylonian empires, brought to light not only a great number of statues and obelisks, bull-colossi and alabaster reliefs, as well as many art-trinkets of gold, silver, bronze, ivory, glass, and precious stones, but also a quantity of literary works of untold age, covering a great variety of subjects. Among these writings are state records, chronological lists, reports of generals and astronomers, letters and petitions, epics and animal fables, prayers and psalms, astronomical and mathematical works, dictionaries and chrestomathies, all written on clay tablets of various shapes, and just as legible now as when they were first engraved. The number of tablets in the royal library of Sardanapalus, of offerings in the Babylonian temples, and of commercial and legal documents of the great mercantile houses of Nippur, Babel, and Lagash, preserved in clay vases, can hardly be estimated. Three thousand years of the lost history of mankind have thus been restored to us. On the development of architecture, plastic art, and painting, on the history of science and religion, of social and economic forms, a brighter light has been thrown and new sources of information have been disclosed to the student of the Bible and ancient history, of philology and the comparative history of law, of astronomy, mathematics, and other branches of science. Koldewey's expedition has increased our store of knowledge of ancient Babylon. The task undertaken by him was the excavation of the mound-ruins in the valleys of the Euphrates and Tigris. At Eastertide of the current year, work was begun at Babylon, the capital of Nebuchadnezzar, the "City of Life" as men called it for three thousand years. From the ruins of this mightiest of ancient cities rises majestically the mound of Al Kasr ("the castle"), identified by thousands of inscribed tablets with the royal palace in which Nebuchadnezzar lived for the greater part of his reign, in which the Achæmenidæ, the conquerors of Jerusalem, passed the winter, and in which Alexander the Great ended his career.

THE CASTLE WALL, VIEWED FROM THE WEST.

According to early Babylonian records, Nebuchadnezzar completed the fortifications of the city, begun by his father Narbolpolassar, consisting of a double inclosure of strong walls, the inner called Imgur-Bel ("Bel is gracious"), the outer Nemitti-Bel ("foundation of Bel"). The circumference of the latter according to Herodotus was 480 stades (55 miles), its height 340 feet, and its thickness 85 feet. At the inner and outer peripheries, one-story houses were built, between which was room enough for a chariot drawn by four horses harnessed abreast. When Koldewey cut through the eastern front of Al Kasr, he came upon a wall which was undoubtedly that described by Herodotus. The outer eastern shell was composed of burnt brick and asphalt, 24 feet in thickness; then came a filling of sand and broken stone 70½ feet in thickness, which was followed by an inner western shell of 43 feet thickness. The total thickness was, therefore, 137·5 feet. By dint of hard work this wall was cut through and the entrance to Nebuchadnezzar's palace laid bare. Koldewey and his men were enabled to verify the description given by Diodorus of the polychromatic reliefs which graced the walls of the royal towers and palaces. It still remains to be seen how trustworthy are the statements of other ancient historians.

The city itself, as previous investigators have found, was adorned with many temples, chief among them Esaglia ("the high towering house"), temple of the city, and the national god Marduk (Merodach) and his spouse Zirpanit. Sloping toward the river were the Hanging Gardens, one of the world's seven wonders, located in the northern mound of the ruins of Babel. The temple described by Herodotus is that of Nebo, in Borsippa, not far from Babylon, which Herodotus included under Babylon and which the cuneiform inscriptions term "Babylon the Second." This temple, which in the mound of Birs Nimrûd is the most imposing ruin of Babylon, is called the "eternal house" in the inscriptions; it was restored by Nebuchadnezzar with great splendor. In form, it is a pyramid built in seven stages, for which reason it is sometimes referred to as the "Temple of the Seven Spheres of Heaven and Earth." The Tower of Babel, described in Gen. x., is perhaps the same structure.

It remains for the German expedition to continue its excavations in Nebuchadnezzar's palace. There is still much in the life work of the great Chaldean that is unknown, much that would illumine many a dark page in the world's history. Perhaps the inscriptions on the walls may give us the information which we lack, and which will tell us something more of a mighty people, long since vanished from the face of the earth.



RUINED BUILDINGS ON THE CASTLE WALL.

VARIATION AND SOME PHENOMENA CONNECTED WITH REPRODUCTION AND SEX.*

IN the following address an attempt is made to treat the facts of variation and heredity without any theoretical preconceptions. The ground covered has already been made familiar to us by the writings of Darwin, Spencer, Galton, Weismann, Romanes and others. I have not thought it advisable to discuss the theories of my predecessors, not from a want of appreciation of their value, but because I was anxious to look at the facts themselves and to submit them to an examination which should be as free as possible from all theoretical bias.

Zoology is the science which deals with animals. Knowledge regarding animals is, for convenience of study, classified into several main branches, among the most important of which may be mentioned: (1) the study of structure; (2) the study of the functions of the parts or organs; (3) the arrangement of animals in a system of classification; (4) the past history of animals; (5) the relations of animals to their environment; (6) the distribution of animals on the earth's surface. That part of the science of zoology which deals with the functions of organs, particularly of the organs of the higher animals, is frequently spoken of as physiology, and separated more or less sharply from the rest of zoology under that heading. So strong is the line of cleavage between the work of the physiologist and that of other zoologists that this Association has thought it advisable to establish a special section for the discussion of physiological subjects, leaving the rest of zoology to the consideration of the old established Section D. In calling attention to this fact, I do not for one moment wish to question the advisability of the course of action which the Association has taken. The science of physiology in its modern aspects includes a vast body of facts of great importance and great interest which no doubt require separate treatment. But what I do wish to point out is that it is quite impossible for us here to abrogate all our functions as physiologists. Some of the most important problems of the physiological side of zoology still remain within the purview of this section.

For instance, the important and far-reaching problems connected with reproduction and variation are very largely left to this section, and that large group of intricate and almost entirely physiological phenomena connected with the adaptations of organisms to their environment are dealt with almost exclusively here. Indeed, we may go further, and say that apart altogether from practical questions of convenience, which make it desirable to separate a part of physiological work from the Zoological Section, it is, as a matter of fact, impossible to divorce the intelligent

*Opening address by Adam Sedgwick, M.A., F.R.S., President of the Zoological Section, British Association.

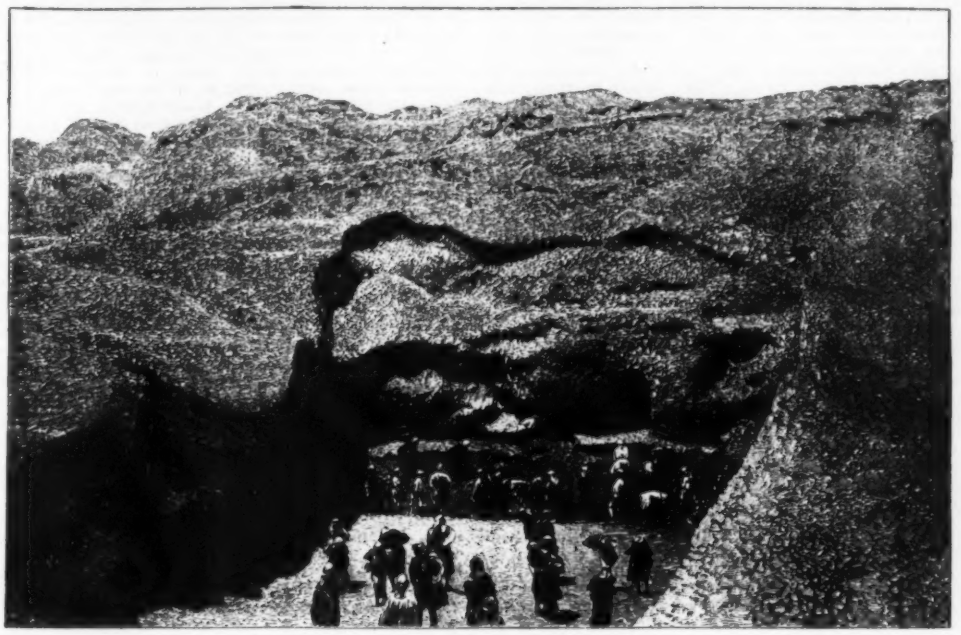
study of structure from that of function. The two are indissolubly connected together. The differentiation of structure involves the differentiation of function, and the differentiation of function that of structure. The conceptions of structure and function are as closely associated as those of matter and force. A zoologist who confined himself to the study of the structure of organisms, and paid no attention to the functions of the parts, would be as absurd a person as a philologist who studied the structure of words and took no account of their meaning. In the early part of this century, when the subject matter of zoology was not so vast as it is at present, this aspect of the case was fully recognized, and one of the greatest zoologists of the century, whether considered from the point of view of modern anatomy, or of modern physiology, was Professor of Anatomy and Physiology at the University of Berlin.

Having said that much as to the various aspects of living nature, of natural history, if you like, which it falls within the province of this section to deal with, I may now proceed to the subject of my address. And when I mention to you what that subject is, you will be able to make some allowance for the somewhat commonplace remarks with which I have treated you. For that subject, though it has its important morphological aspects, is in the main a physiological one; at any rate, no study which does not take account of the physiological aspect of it can ever hope to satisfy the intellect of man. The subject, then, to which I wish to draw your attention at the outset of our proceedings, is the great subject of Variation of Organisms.

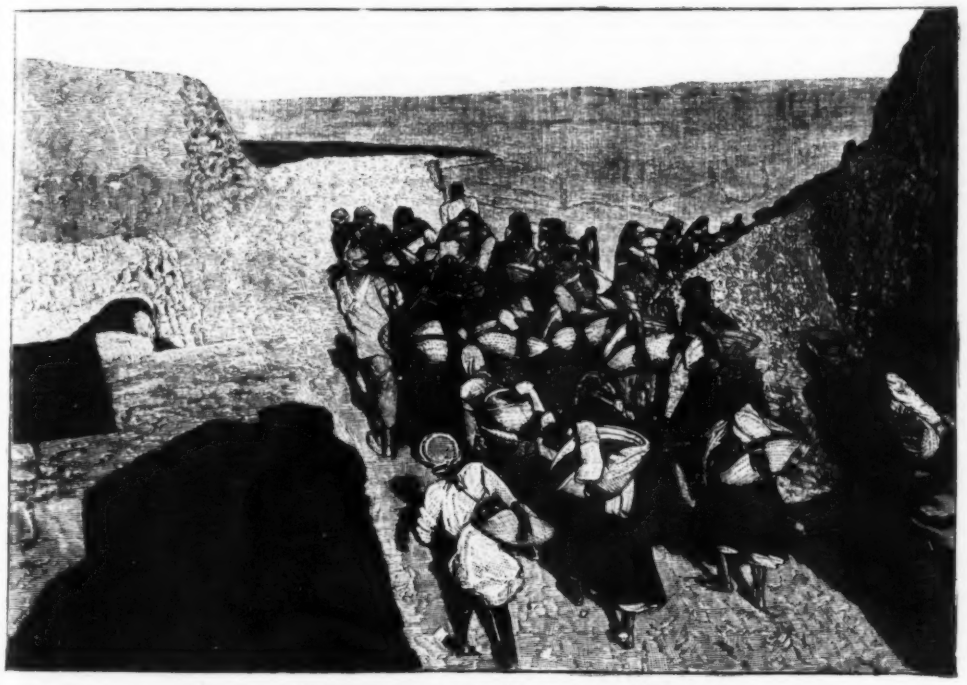
As every one knows, there is a vast number of different kinds of organisms. Each kind constitutes a species, and consists of an assemblage of individuals which resemble one another more closely than they do other animals, which transmit their characteristics in reproduction and which habitually live and breed together. But the members of a species, though resembling one another more closely than they resemble the members of other species, are not absolutely alike. They present differences, differences which make themselves apparent even in members of the same family, i.e., in the offspring of the same parents. It is these differences to which we apply the term variation. The immense importance of the study of variations may be judged from the fact that, according to the generally received evolution theory of Darwin, it is to them that the whole of the variety of living and extinct organisms is due. Without variation there could have been no progress, no evolution in the structure of organisms. If offspring had always exactly resembled their parents and presented no points of difference, each succeeding generation would have resembled those previously existing, and no change, whether backward or forward, could have occurred. This phenomenon of genetic variation forms the bedrock upon which all theories of evolution must rest, and it is only by a study of variations, of their nature and cause, that we can ever hope to obtain any real insight into the actual way in which evolution has taken place. Notwithstanding its importance, the subject is one which has scarcely received from zoologists the attention which it merits.

Though much has been written on the causes of variation, too little attention has of late years been paid to the phenomenon. Since the publication of Darwin's great work on the "Variation of Animals and Plants under Domestication," there have been but few books of first-rate importance dealing with the subject. The most important of these is Mr. William Bateson's work, entitled "Materials for the Study of Variation." I have no hesitation in saying that I regard this work as a most important contribution to the literature of the evolution theory. In it attention is called, with that emphasis which the subject demands, to the supreme importance of the actual study of variation to the evolutionist, and a systematic attempt is made to classify variations as they occur in nature. In preparing this book, Mr. Bateson has performed a very real service to zoology, not the least part of which is that he has made a most effective protest against that looseness of speculative reasoning which, since the publication of the "Origin of Species," has marred the pages of so many zoological writers.

The variations of organisms may be grouped under two heads, according to their nature and source: (1) There are those variations which appear to have no relation to the external conditions, for they take place when these remain unchanged, e. g., in members of the same litter; they are inherent in the constitution of the individual. These we shall call constitutional variations, or as their appearance seems nearly always to be connected with reproduction, they may be called genetic (congenital, blastogenic) variations. (2) The second kind of variations are those which are caused by the direct action of external conditions. These variations constitute the so-called acquired characters.



THE EASTERN CASTLE WALL.



LABORERS CARRYING AWAY SAND.

My first object is to consider these two kinds of variations, their nature, their causes, and their results on subsequent generations, and to inquire whether there are any fundamental differences between them. In this connection it is of particular importance that we should inquire whether acquired modifications are transmitted in reproduction. As is well known, there are two schools of thought holding directly opposite views as to this matter. The one of these schools—the so-called Lamarckian school—holds that they may be transmitted as such in reproduction; the other school, on the other hand, maintains that acquired modifications affect only the individual concerned, and are not handed on as such in reproduction. That the decision of the matter is not only theoretically important, but also practically, is evident, for upon it depends the answer to the question whether mental or other faculties acquired by the laborious exercise of the individual are ever transmitted to the offspring—whether the facility which the individual acquires in resisting temptation makes it any easier for the offspring to do the same, whether the effects of education are cumulative in successive generations. To put the matter as Francis Galton has put it, Is nature stronger than nurture, or nurture than nature?

We have then two kinds of variation to consider: (1) genetic variation, (2) acquired modification. It is the former of these—namely, genetic variation—with which I wish primarily to deal. Let us examine more fully the mode of its occurrence.

GENETIC VARIATION.

Organized beings present, as you are aware, two main kinds of reproduction, the sexual and the asexual. These two kinds of reproduction present certain differences, of which the most important, and the only one

HOUSE OF THE GERMAN ASSYRIOLOGISTS.

which concerns us now, is the fact that genetic variation is essentially associated with sexual reproduction, and is rarely, if ever, found in asexual reproduction. In other words, whereas the offspring resulting from asexual reproduction as a rule exactly resemble the parent, they are always different from the parents in sexual reproduction. I am aware that I am treading on disputed ground. You will observe that I do not make the assertion that asexually produced offspring always exactly resemble the parent, and never present genetic variations. To say that would be going too far in the present state of our knowledge. Therefore I have put the matter less strongly, and merely assert that whereas asexual reproduction is on the whole characterized by identity between the offspring and the parent, sexual reproduction is always characterized by differences more or less marked between the two; and I reserve the question as to whether genetic variations are ever found in asexual reproduction for later consideration.

This modified form of the statement will, I think, be admitted on all hands, but before going on I will illustrate my meaning by reference to actual examples.

Asexual reproduction is a phenomenon comparatively rare in the animal kingdom, and when it does occur it is exceedingly difficult to investigate from this particular point of view. In the vegetable kingdom, on the other hand, it is quite common. All, or almost all, plants possess this power, and in a very great many of them the result of its exercise can be fully followed out and contrasted with that of sexual reproduction. Let us follow it out in the potato plant. The potato can and does normally propagate itself asexually by means of its underground tubers. As you will know, if you take one of these and plant it, it gives rise to a plant exactly resembling the parent. If the tuber (seed as it is sometimes erroneously called) be that of the Magnum Bonum, it gives rise to a plant with foliage, flowers, and tubers of the Magnum Bonum variety; if it be of the Snowdrop, the foliage, flowers, habit, and tubers are totally different from the Magnum Bonum and are easily identified as Snowdrops. In this way a favorable variety of potato can be reproduced to almost any extent with all its peculiarities of earliness or lateness, pastiness or mealiness, power of resisting disease, and so forth. By asexual reproduction the exact facsimile of the parent may always be obtained, provided the conditions remain the same.

Now let us turn to the results of sexual reproduction—the seeds, i. e., the real seeds, which as you know are produced in the flowers, are the means by which sexual reproduction is effected. They are produced in great quantity by most plants, and when placed in the ground under the proper conditions, they germinate and produce plants. But these plants do not resemble the parent. Try the seed of the Magnum Bonum potato and raise plants from it. Do you think that any of them will be the Magnum Bonum with all its properties of keeping, resisting disease, and so forth? Not a bit of it. The probability is that not one of your seedling plants will exactly reproduce the parents; they will all be different.

Again, take the apple; if you sow the seed of the Blenheim orange and raise young apple trees, you will not get a Blenheim orange. All your plants will be different, and probably not one will give you apples with the peculiar excellence of the parent. If you want to propagate your Blenheim orange and increase the number of your trees, you must proceed by grafting or by striking cuttings, which are the methods by which such a tree may be asexually reproduced. And so on.

Examples might be multiplied indefinitely. Every horticulturist knows that variety characterizes seedlings, i. e., sexual offspring, whereas identity is found in slips, grafts, and offsets, i. e., in asexual offspring; and that if you want to get a new plant you must sow seeds, while if you want to increase your stock of an old one you must strike cuttings, plant tubers, or proceed in some analogous manner.

An apparent exception to this rule is afforded by so-called bud variation, but it is not certain that this is really an exception. In so far as these bud variations are not of the nature of acquired variations produced by a change of external conditions, and disappearing as soon as the old conditions are renewed, they are probably stages in the growth and development of the organism. That is to say, they are of the same nature as those peculiarities in animals which appear at a particular time of life, such as a single lock of hair of a different color from the rest of the hair,* the change in color of hair with growth,† the appearance of insanity or of epilepsy at a particular age. There is nothing more remarkable in a single bud on a tree departing from the usual character at a particular time of life, than in a particular hair of a mammal doing the same thing.

We have seen that, speaking broadly, genetic variation is connected with sexual reproduction, and it becomes necessary to examine this mode of reproduction a little more fully. What is the essence of sexual reproduction, and how does it differ from asexual? What I am now going to say applies generally to the phenomenon, whether it occurs in plants or animals. Sexual reproduction is generally carried on by the cooperation of two distinct individuals—these are called the male and female respectively. They produce, by a process of unequal fission which takes place at a part of their body called the reproductive gland, a small living organism called the reproductive cell. The reproductive cell produced by the male is called, in animals, the spermatozoon, and is different in form from the corresponding cell produced by the female, and called, in animals, the ovum. The object with which these two organisms are produced is to fuse with one another and give rise to one resultant uninucleated organism or cell, which we may call the zygote. This process of fusion between the two kinds of reproductive cells, which are termed gametes, is called conjugation. The difference in structure between the male and female gamete is a matter of secondary importance only, and is connected with the primary function of coming into contact and fusing. The same may be said with regard to the so-called sexual differences of the parents of the two kinds of gametes and to the powerful instincts which regulate their action. The conjugation of the male and female gamete, or the fertilization of the ovum, as it is sometimes called, consists in the fusion of two distinct masses of protoplasm which are nearly always produced by different individuals. In the case of hermaphrodites, the term applied to organisms which produce both male and female gametes in the same individual, there is generally some arrangement which tends to prevent the male gamete from conjugating with the female gamete of the same parent; but this phenomenon is not absolutely excluded, and takes place as a normal phenomenon in many plants and possibly in some animals.

This fusion of the protoplasm of the two gametes gives us an uninucleated organism—for the fusion of the nuclei of the two gametes seems to be an essential part of the process—in which the potencies of the two gametes are blended. The zygote, as the mass formed of the fused gametes is called, is formed by the combination of two individualities, and is therefore essentially a new individuality, the characters of which will be different from the characters of both of the parents. This fact, which is not apparent in the zygote when first established, because the parts are hardly distinguishable by our senses, becomes obvious as soon as organs, with the appearance of which we are familiar, are formed. As a general rule, this cannot be said to have occurred until what we call maturity has been nearly reached, because we are not familiar enough with the features of immature organisms to detect individual differences. But you may rest assured that such differences exist at all stages of growth from that of the uninucleated zygote till death. How the characters of the two parents will combine in the zygote it is impossible to predict, and the result is never the same even though the conjugations have been between gametes of identical origin. There may be an almost perfect mixture, the blending extending to even quite minute details; or the characters of the one parent may predominate—be prepotent, as we call it—over those of the other; or they may blend in such a way that the zygote offers characters found in neither parent. Or, finally, the features of one parent may come out at one stage of growth, those of the other at another stage. But, however the characters may blend, the product never exactly resembles the parents. The extent to which it differs from them is the measure of the variation.

To resume, it will be observed that in the method of reproduction sometimes called sexual, two distinct processes occur. One of these is the real reproductive act, which consists in the production by fission of uninuclear individuals called gametes; the second is the fusion of the gametes to form the zygote. The gametes are of two kinds, and the reason of their being two kinds is intelligible when we consider the parts they have to play. The male gamete is nearly always endowed with locomotive power, and the female gamete is stored with food material to be used by the zygote in the first stages of growth. The destiny of these two uninucleated organisms is to fuse with one another, and so to give rise to a zygote which ultimately assumes the typical form of the species. As a general rule, the gametes have but a limited duration* of life unless they conjugate, and this is quite intelligible when we remember that they have no organs, e. g., digestive organs, suitable for the maintenance of life. It is rarely found that they have the power of assuming the form of their parent unless they conjugate. This never happens in the case of the male gamete (at any rate in animals), and only rarely in that of the female. When it occurs—that is to say, when the ovum develops without conjugation — we call the phenomenon parthenogenesis. Parthenogenesis is found more commonly in Arthropods than in other groups, but it may be more common than is supposed.†

In sexual reproduction, then, in addition to the real reproductive act, which is the division by fission of the parent into two unequal parts, the one of which continues to be called the parent, while the other is the gamete, there is the subsequent conjugation process. It is to this conjugation process that that important concomitant of sexual reproduction must be attributed, namely, genetic variation. We have thus traced genetic variation to its lair. We have seen that it is due to the formation of a new individuality by the fusion of two distinct individualities. We have also seen that in the higher animals it is always associated with the reproductive act.

Let us now take a wider survey and endeavor to ascertain whether this most important process, a process upon which depends the improvement as well as the degradation of races, ever takes place independently of the reproductive act. In the Metazoa, to which for our present purpose I allude under the term higher animals, conjugation never takes place except in connection with reproduction. It is impossible from the nature of the process that it should do so, as I hope to explain later on. But among the Protozoa, the simplest of all animals, it is conceivable that conjugation might take place apart from reproduction, and as a matter of fact it does do so. Let us now examine a case in which this occurs. Among the free-swimming ciliated Infusoria it frequently happens that two individuals become applied together, and that the protoplasm of their bodies becomes continuous. They remain in this condition of fusion for some days, retaining, however, their external form and not undergoing complete fusion. While the continuity lasts there is an exchange of living substance between the two bodies, in which exchange a bit of the nucleus of each participates.

It thus happens that at the end of conjugation, when the two animals separate, they are both different from what they were at the commencement; each has received protoplasm and a nucleus from its fellow, and the introduced nucleus fuses as we know with the nucleus which has not moved. It would therefore appear that all the essential features of the conjugation process, as we learnt them in the case of the conjugation of the gametes in the Metazoa, are present, and it is impossible to doubt that we have here an essentially similar phenomenon. The phenomenon differs, however, from the conjugation first described in this interesting and important respect, that the two animals separate and resume their ordinary life. It is true that their constitution must have been profoundly changed, but they retain their general form. I say that the constitution of the exconjugates, as we may call them after they are separated, must be different from what it was before conjugation, but so far as I know no difference in structure corresponding with this difference in constitution has been recorded. I feel no sort of doubt, however, that structural differences, i. e., variations, will be detected when the exconjugates are closely scrutinized and compared with the animals before conjugation, and I would suggest that definite observations be made with a view to testing the point. Here, then, we have a case of conjugation entirely dissociated from reproduction. Other cases of a similar character are known among the Protozoa, though as a general rule the fusion between the conjugating organisms is complete and permanent. Among plants conjugation is generally associated with reproduction, but not always, for in certain fungi* fusion of hyphæ and consequent intermingling of protoplasm occurs, and is not followed by any form of reproduction. Among bacteria alone, as far as I know, has the phenomenon of conjugation never been observed.

To sum up, we have seen that the phenomenon of conjugation is very widely distributed. Excluding the bacteria, there is reason to believe that it forms a part of the vital phenomena of all organisms. Its essential features are a mixture and fusion of the protoplasm of two different organisms, accompanied by a fusion of their nuclei. It results in the formation of a new individuality, which differs from the individualities of both the conjugating organisms. This difference manifests itself in differences in habit, constitution, form, and structure, such differences constituting what we have called genetic variations.

The conjugation of the ovum and spermatozoon in the higher animals, and the corresponding process in the higher plants, are special cases of this conjugation, in which special conjugating individuals are produced, the ordinary individuals being physically incapable of the process. The phenomenon of sex, with all its associated complications, which is so characteristic of the higher animals and plants, is merely a device to insure the coming together of the two gametes. In the lower animals, it is possible for the ordinary organism to conjugate; consequently the phenomenon does not form the precursor of developmental change and is in no way associated with reproduction. Indeed, in such cases it is often the opposite of reproduction, inasmuch as it brings about a reduction in the number of individuals, two separate individuals fusing to form one.

(To be continued.)

* Darwin, "Variation," vol. i., p. 449.

† As an example I may refer to the Himalayan rabbit; Darwin, "Variation," vol. i., p. 114.

* Under favorable conditions they may live a considerable time, e. g., the spermatozoon of certain ants, which are stated by Sir John Lubbock to live in some cases for seven years.

† It may be mentioned as a curious fact that parthenogenesis is rarely found in the higher plants, and, as I have said, is not known for the male gamete among animals.

* It must be mentioned, however, that in the case of these fungi the fusion of nuclei has not been observed, nor has it been noticed whether the habit, structure, or constitution of the conjugating plants are altered after the fusion.

THE DEVELOPMENT OF IRON MANUFACTURE IN THE UNITED STATES IN THE PAST SEVENTY-FIVE YEARS.†

By John Fritz, Honorary Member of the Institute, Bethlehem, Pa.

[Introductory.—It was my intention to have given a brief account of the early experiments with the Bessemer process at Cambria and Wyandotte, and also a brief notice of the earlier works that went into the business. I soon found, however, that it was not possible to do so in a paper such as I was called on to read, and, besides, Mr. Wm. F. Durfee and Mr. R. W. Hunt, who each by turns had charge of the experiments at Wyandotte, have already put the general results on record. Consequently, I will confine myself to such a paper as I was called to give—some personal reminiscences of my connection with the manufacture of iron and steel, which is unfortunate for me, as I would much prefer to tell what others have done than what I have done myself. But, as I was asked to do this by the officers of your society, and did not seek the honor, I beg you will, as far as possible, excuse what will doubtless seem somewhat egotistical, and ask you to bear in mind that what I have to say is only a general history of the early developments of the iron and steel industry in this country, which others also had much to do with.—J. F.]

I have been requested by your President, Mr. Birkinbine, and also by Mr. Christie, chairman of the Mining and Metallurgical Section of the Institute, to give some reminiscences concerning the progress that has been made in iron and steel metallurgy in my lifetime and during the lifetime of the Franklin Institute.

This being the last year but one of the century that has done so much to change the face of society, and for the betterment of mankind, it will be interesting to take a brief retrospective view of the events that have taken place during this remarkable period, and in doing so we witness the most wonderful progress that has been made in the advancement of the arts of science and civilization, all the effects of which are far-reaching.

In the very front we see the phenomenal progress that has been wrought in all the various branches of manufacture in all parts of the civilized world. We look again and find that the manufacture of iron is in the lead, and that the United States comes in for a large share of this all-important branch of manufacturing industry, which is the advance guard of civilization, one which has done so much to build up this country and served her so well both in peace and in war.

While I have not been asked to say anything about matters beyond the date of my own experience or the life of the Institute, it seems necessary, however, that a brief allusion should be made to the first puddling furnace and plate mill that were erected, in order that the great advance that has been made in this branch of the manufacture may be more fully appreciated.

The first puddling furnace in this country was built

† An address delivered in Convention Hall, National Export Exposition, Wednesday, October 4, on the Occasion of the Celebration of the Seventy-fifth Anniversary of the Franklin Institute.

at Plumsock, on Redstone Creek, about midway between Connellsville and Brownsville, in Fayette County, Pa., in 1817. A flood caused the partial destruction of this mill. The machinery was subsequently removed to Brownsville. In 1819, a rolling mill was built at Pittsburg in which there were four puddling furnaces. This mill was accidentally blown up, and permanently dismantled in 1829, and the machinery was taken to Covington, Ky. Both enterprises thus seem to have ended in disastrous failures.

About 1810 Isaac Pennock built a rolling mill (at that time called a "slitting mill") near Coatesville, in Chester County, Pa. In 1816 it came into the hands of Dr. Charles Lukens, a son-in-law of Isaac Pennock, and was operated by him until his death in 1825. It was during this period and on this mill that the first boiler plate was rolled in this country. The blooms were heated on a grate fire and the rolls were driven by an old-time undershot water-wheel. When a boy I heard the older men say that the mill was often short of power, and frequently all the workmen would run and get on the buckets and tread with them, in order to prevent a stall which would have caused fire cracks in the rolls, and sooner or later a broken roll. This being before the days of railroads, coal was hauled from Columbia, thirty-five miles distant, and the plates were teamed to Philadelphia, thirty-five miles away, and were shipped without being sheared. A notable circumstance about these works is the fact that they have always remained in the family of Isaac Pennock, and are now operated by his descendants of the fourth generation.

What I have now said will be sufficient to give you some idea of the condition of the trade at that time, and will enable you better to appreciate the great improvements that afterward were made; and also brings us practically down to the birth of the Institute in 1824.

From 1824 until 1836 but little progress was made in the way of marked improvements. During the thirties there were some puddling furnaces built, to puddle run-out or refined pig metal, and eventually they got in the way of using some close grain pig iron in connection with the refined metal.

In the early forties puddling began to come into general use, but only close iron was used. In the years 1844-45 the manufacture of rails commenced. This at once gave it the leading position in the manufacture of iron, which it held until it was beaten by the Bessemer process, to which I shall refer again.

About this time the manufacturers' trouble begins. The demand for puddlers soon exceeded the supply, and they thought they ought to have things their own way. Up to this time the old-fashioned Welsh hammer was the only mode in use for putting the puddled ball in shape for the rolls. The hammerman or "shingler," as he was called at that time, was the king bee, and when he went wrong, as he frequently did, the puddlers had to quit work until such a time as Mr. "Shingler" was ready to go to work, which sometimes required several days; and when at work wo be unto the puddler who might happen to be on bad terms with him.

The hammer striking a uniform blow, no coaxing could be done; consequently great skill was required during the first few strokes of the hammer to keep the ball in such shape that it could be edged and upended in order to get a good shaped and compact bloom. Should the "shingler" fail in this, which he could and at times did, and that without any apparent intention, then a row was started which sometimes ended in a fisticuff, as we had bullies in those days as well as now, but not so well trained, and the rules of the ring were not such as they are to-day; if they had been, they would not have been strictly adhered to.

The next improvement in this line was the introduction of what was known as the "crocodile" squeezer, which was entirely unlike the hammer in every way, and it was so easily worked that almost any of the puddlers could put their own work in shape; but, unfortunately for the manufacturer, they could coax a ball into shape that was not properly worked in the furnace. So, while this was entirely satisfactory to the puddler, it was very unsatisfactory and unprofitable to the manufacturer, with the result that there was constant bickering between the employers and employés; a condition of affairs that should not exist.

Next came the "Burden" and "Winslow" squeezers; the latter was used for a time, but finally the "Burden" came into general use, and is to this day as nearly perfect a machine for the purpose intended as has ever been devised. Not alone on account of its simplicity in construction and the perfect manner in which it does its work, but because, also, it establishes justice between the ironmaster and the workmen, from which there is no attempt to make an appeal. When a ball would break, the workman, without saying a word, gathered together the pieces and took them back to the furnace and worked them into a proper condition, and in the end the squeezer proved to be the puddler's friend. Notwithstanding all its good qualities, its introduction caused strife in practically all the mills that introduced it down to about the year 1856. Some of the strikes were long and bitter, and many incidents might be recited in relation to its introduction, some amusing, some ridiculous, and others revengeful. However, soon after the system came into general use, an armistice was agreed upon, which finally resulted in a treaty of peace, which was advantageous to both parties.

In or about the year 1848, boiling came into general use, which was a great improvement, and puddling soon became the all-important branch of the great iron industry of the country, and continued in the lead until it was overtaken by the almost magical invention of Sir Henry Bessemer, to which I shall refer later.

Until 1840 all the pig iron produced in the United States was made with charcoal. My first connection with a furnace dates from 1839. It was driven by water, a wooden blowing-cylinder connected with the crank by a wooden beam. The crank, the journal and the wings that were fitted in the end of the water-wheel shaft to carry the wheel and to drive the blowing cylinders. Neither of the journals was turned off, but were put to work just as they came out of the sand. It was blown by an open tuyere. The whole plant was of the crudest construction. The weekly make was about sixteen to twenty tons. It was placed against a bank, level with the tunnel-head, so as to avoid hoisting the material up. This was about the character of the furnaces in general use at that time.

I was sent there as a "cub" to put up a belly-pipe which was made at the shop in which I was learning my trade. When it was put in place it was, as I remember, about six or eight inches too short, and I supposed somebody had made a mistake in the length. The founder was a consequential-looking man, and quite stout, with a blue flannel shirt and his "pants" held up by a rather broad leather band buckled around his body, somewhat in the order of many we see to-day, but was not gotten up in the same style. He said rather brusquely that "it was all right." The pipe was connected at the rear end to the main pipe by a short leather connection, which I was told was to allow the belly-pipe to swing out of the way so that they could get the cinder out.

This was the general condition of the furnaces until 1840, when Mr. David Thomas, since affectionately called "Father Thomas," made the first anthracite iron in a commercial way that was made in this country. This was the commencement of the phenomenal development of the blast furnace practice that has taken place in the latter part of this century.

We left the rolling mills in 1824 in a very crude condition, and there was no marked improvement in them until the manufacture of rails commenced, which, as already mentioned, was about 1844. But even at this time the plans of the mill and manner of building practically remained the same, being geared, and it seemed to me that the general impression among the rolling mill proprietors was that the more wheels they could get in, the better was the mill. Down to this time the carpenter or millwright had largely the say, consequently wood was much used. The shafts were generally made square, and the fly-wheel and gear-wheels were secured on them by the use of wooden wedges, into which other thin wedges of iron were driven. No matter if the foundation was built of wood or stone, a large piece of timber was placed on top, to which the housings were secured; the idea being that it was essential that the train should have some elasticity in order to take the shock off the machinery, thereby preventing breakage.

After the manufacture of rails commenced in 1844, more rigid and better workmanship was required. The mills, as heretofore, were all geared, but the carpenter and millwright were superseded by the machinist. The shafts were now turned up, wheels were bored out, and the mill all fitted up in a more workmanlike manner.

From 1845 to 1856 there were but few improvements made, either in machinery or the manner of rolling, except the introduction of the rail-straightening machine which took the place of the sixty-pound sledge and a special man to handle it. When he wanted a rest, the works had to come to a standstill until such a time as he was completely rested, sobered up, or restored to health, as the case might be.

The year 1857 is a memorable period in the history of the manufacture of iron. As before stated, in 1844 the forge carpenter and millwright were superseded by the machinist, who now comes to the front as a mechanical engineer, not full fledged, but with an amount of knowledge gained by experience which qualified him for the important duty which awaits him.

As I have already said, the year 1857 was a memorable period in the history of the manufacture of iron. Down to this time all the rails were rolled on a two-high train, the pile being passed back over the top roll, which meant a great waste of time and loss of heat. When the flanges once began to crack, which was one of the serious troubles, being all the time rolled in one direction, it greatly aggravated the difficulty. The result was that when an imperfection occurred in the flange, the trouble increased with each pass through the rolls, and so extended that it was a common occurrence for the flange to tear off the whole length of the rail and wind around the roll, forming what, in rolling mill parlance, was called a collar, which very generally ended in breaking some part of the train and often the roll.

The iron was frequently both red and cold-short and all other shorts, and in addition to this would stand but little heat, consequently the end of the pile which entered the roll first would split and open out like the mouth of an alligator. Then, of course, it would not enter the rolls without force, which was applied with the buggy, using it as a battering ram. After making several vain attempts to get it to enter the rolls, it very frequently had to be turned end for end. The loss of time taken up in going through all this was such that it was almost an impossibility to get a perfect rail. Had it not been for the use of putty, oxide of iron and the absence of inspectors, there would have been but few rails shipped.

In order to get over the difficulty of the flanges tearing off, we went to quite an expense. Some iron of a better quality was used for the flanges, which, in a measure, gave some relief in that direction. But the iron being much stronger required more heat and greatly increased the difficulty of opening the end of the pile in the first few passes. We were now in a sad dilemma, and something had to be done. I was sick at heart, and had it been manly, I would have run away.

But, during all this time, I was giving the subject much consideration, and had fully made up my mind that if a three-high mill could be made to work, the difficulties could all be overcome; I, besides, had made up my mind that it was the only proper way to roll iron.

I was now prepared to suggest the building of a three-high mill, which I did; and the suggestion was met with a rebuff, which was not unexpected. They said in substance: "It was a visionary scheme; it had never been done, and had it been practical it would have been done long ago." In reply, I told them something must be done or there would be a large funeral, and I did not want to be one of the mourners. The subject was then more seriously taken up by the company, and it was suggested that a better ore should be secured as a mixture to improve the quality of the iron; but the location of the works was such that a suitable ore could not be got at a price that would permit it to be used as a rail mixture, so this course was abandoned.

The company now began to see that it was necessary that something should be done. The directors called a meeting and, after consultation with some practical iron men, decided to put up a geared two-high mill, and by greatly increasing the speed of the rolls, the rail would be finished in much less time, and consequently at a higher heat, which would prevent the serious trouble of rough and torn flanges. After some pertinent discussion, I was ordered to build a new mill, two-high, geared. As my patience had become exhausted, and being thoroughly disgusted and especially so with the geared mill, I most emphatically said I would not do it, as two of the most objectionable features of the present system would still be retained. I was then asked what right I had to dictate to the company in regard to the policy they should pursue in the line of their business. I answered that I had no right whatever, but that I was thoroughly convinced that it would not remove the difficulty and in the end would be a failure and the result financial disaster. Being a young man and the only capital I had in the world being my reputation, and that being quite limited, I did not purpose placing it in danger where the chances were so unequal. This interview ended in a suspension of hostilities, and for a short time nothing was said on either side. But the trouble in the mill still continued, and something must be done, and quickly. Having already lost my reputation for complaisance and being considered as the most arbitrary of men they had ever met, I consequently concluded that I would do as I had been compelled to do before and many times since—assume authority and go ahead, which I did; and commenced work on the patterns. The drawings had already been practically completed.

After the pattern for the housing was well advanced, Mr. E. Y. Townsend, the vice-president, came out to the works, and I informed him of what I was doing, and again talked the situation over with him. He said nothing, but thought it proper to let the company know what was being done, to which I assented. In about a week, as I remember, he came to the works again. This time he was armed with a legal document opposing the spending of the money in the way it was being done. He handed me the document to read, which I did. I then handed it back to him and said nothing. He then asked me what I thought about it and the best course to pursue. In answer, I said: "You know the troubles we have had, and it is useless to go over them again, and you know my opinion, which is irrevocable." After some friendly talk on the condition and the importance of the change proposed, he said: "Go ahead and build the mill as you want it." I asked: "Do you say that officially?" to which he replied: "I will make it official." And he did so.

When I look back to that eventful interview, which took place on a Sunday morning long years ago, and recall to mind Mr. Townsend and myself, with evidences of failure on all sides, and surrounded by the gloom of future uncertainties, I cannot but feel it was the most critical period not only in my own career, but also in that of the Cambria Iron Company.

And here I wish to say that to Mr. E. Y. Townsend belongs the credit not only of the introduction of the three-high rolls, but also for a large share of the subsequent marvelous prosperity of the Cambria Iron Company, which followed the introduction of the three-high mill and its many accompanying improvements.

The opposition to the three-high mill now came in from all quarters. The heaters on the rail mill were unanimous in their condemnation, and waited on the company to tell them what a direful failure it would be. Next I had to meet the combined prejudice of the ironmasters, who were a power at that time. Some of them would tell the managers that the whole thing was certain to be a failure. Next came my friends, in the trade and out of it, begging me to abandon what would surely prove a failure and blast my reputation for life. One of my dearest friends, with whom I had been employed for a number of years, came to see me and, if possible, to get me to change my plans. To them all I said: "No, I can make it work, and it is the only plan that can be adopted that will save the company."

After all these years there is no person other than myself who can fully appreciate the trying position the managers were in. On the one hand, I was to build a mill on an untried plan, and absolutely refused to build the mill they asked for, knowing full well that only in a small degree would it remedy the trouble, and that the money spent on such a plant would be thrown away. On the other hand, there was a strong party of stockholders, protesting in the most positive manner against going on with my plans, and notifying the managers that they would hold them personally liable for all the loss and damage that might grow out of their unwise action, as they considered this action to be in adopting a new and untried method that was against all practice in this and the old country, for at that time we were expected to be followers instead of leaders. Notwithstanding all the opposition and trouble we had to encounter, the work on the mill was being pushed along as fast as it was possible. But there were many difficulties in the way. The most serious was the want of proper tools and facilities for doing the work. Many makeshifts had to be improvised, which all required time and labor. During all this time there was much talk and speculation going on in regard to the final result, to all of which I gave but little attention.

At length the mill was completed, and on the third day of July, 1857, the old mill was shut down for the last time. On the fifth we commenced tearing the old mill out, as the new one had to be put in the same place. The work was pushed as fast as possible, day and night, but, as it was before the days of electric lights, the night work could not be done with the same expedition as to-day. At the same time everything in the rail department was remodeled and the floor line of the mill was raised 2 feet. On the 29th of the same month everything was completed and the mill ready to start. The starting of the mill was the crucial period.

In giving an account of the starting of the mill, I can probably do no better than quote from a paper written for a former occasion:

There were no invitations sent out. As the heaters to a man were opposed to the new kind of mill, we did not want them about at the start. We, however, secured one of the most reasonable of them to heat the piles for a trial. We had kept the furnace hot for

several days as a blind. Everything being ready, we charged six piles. About ten o'clock in the morning the first pile was drawn out of the furnace and went through the rolls without a hitch, making a perfect rail. You may imagine what my feelings were as I looked upon that first and perfect rail ever made on a three-high train.

And you may know in part how grateful I felt toward the few faithful men who were about me, and who had stood by me during all my trials and difficulties. Among these were Alexander Hamilton, the superintendent of the mill, and Thomas Lapsley, who had charge of the rail department, William Canam and my brother George, all of whom have gone to their reward.

We now proceeded to roll the other five piles. When

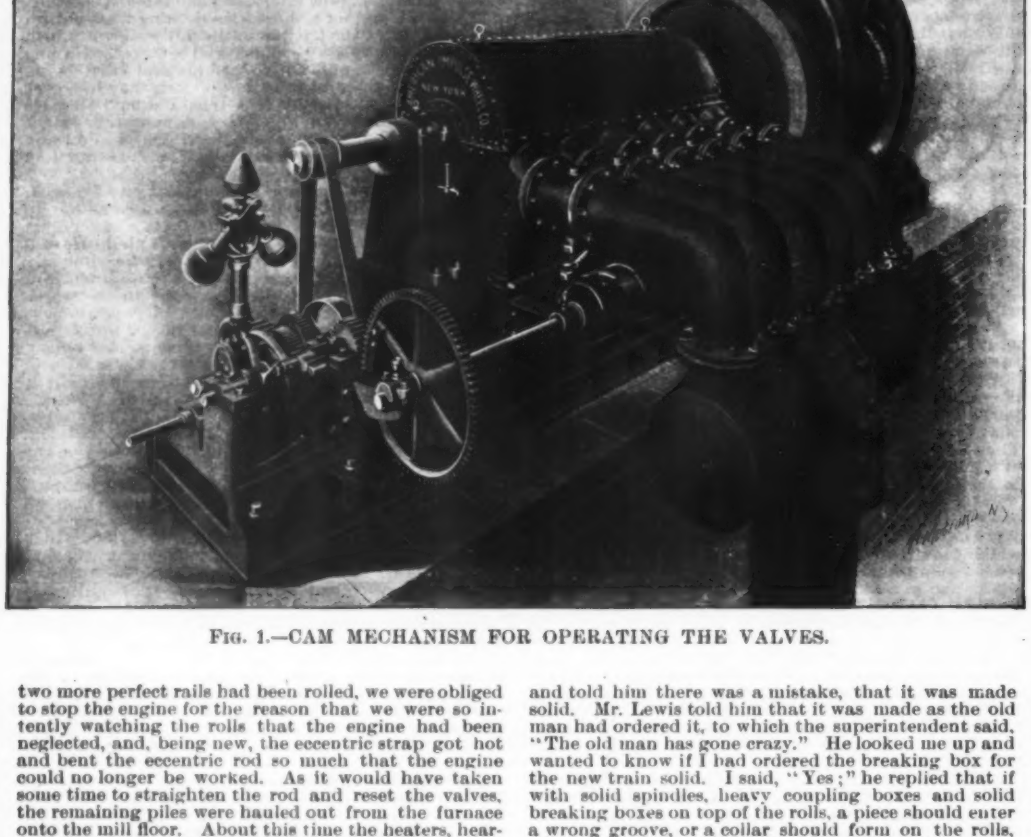


FIG. 1.—CAM MECHANISM FOR OPERATING THE VALVES.

two more perfect rails had been rolled, we were obliged to stop the engine for the reason that we were so intently watching the rolls that the engine had been neglected, and, being new, the eccentric strap got hot and bent the eccentric rod so much that the engine could no longer be worked. As it would have taken some time to straighten the rod and reset the valves, the remaining piles were hauled out from the furnace onto the mill floor. About this time the heaters, hearing and seeing the exhaust of the engine, came into the mill in a body from the opposite end of the mill to where the rails were. Seeing the unrolled piles lying on the floor, they took it for granted that the new train was a failure; and their remarks about it were far from being complimentary. Mr. Hamilton, coming up and hearing what they were saying about the mill, turned around, and using language more pointed than polite, told them if they would go to the other end of the mill they would see three handsomer rails than had ever been made in their country—Wales. After getting the engine in shape, the day being Friday, we ran all day, and at night put the regular night turn on.

Everything worked well up to noon on Saturday, it being our custom to stop rolling at that time. About six o'clock in the evening Mr. Hamilton and myself left the mill, and on our way home congratulated ourselves on the fact that our long line of troubles and disappointments was now over. About an hour later I heard the fire alarm whistle blow, and rushing back to the mill found it one mass of flames from end to end. In less than one hour's time the whole building was burned to the ground, and a story was started that the new mill was a failure, and that we had burned the mill to hide our blundering mistakes. The situation of affairs on that Saturday night was such as might appal the stoutest heart. The product of our labors and anxieties lay there a mass of black and smoking ruins, and the money that was so hard to get with which to build the mill was gone. The prospect was indeed gloomy, but there was one gleam of light amid all the darkness; and that the pile of perfect and new rails, which, as Mr. Hamilton had said, had never been beaten in Wales, from which country the greater part of the rails used at that time came. Above all, the mill had been tried and found to work magnificently, and it was these two facts that gave us all fresh courage, and enabled us to rebuild the mill.

The next day being Sunday, it was devoted to rest and to thinking over the matter. On Monday morning we commenced to clear up the wreck, all the workmen giving a full day toward it, and began the work of rebuilding. In four weeks from that time the mill was running and made 30,000 tons of rails without a hitch or break of any kind, thus making the Cambria Iron Company a great financial success, and giving them a rail plant far in advance of any other plant in the world. This position they held unquestioned, both for quality and quantity, until the revolutionary invention of Sir Henry Bessemer came into general use.

In the construction of the three-high mill there were many changes and improvements on the old two-high mill. Up to this time the leading spindles had a groove cut in them to weaken them, so that if any extra strain should come on the rolls, they would break instead of the roll; and the couplings were made light so as to act as a kind of a safety-valve. Then there was a breaking box placed between the screw and the roll. If there was not one of these safety devices breaking each day, the pattern was made lighter. The result was that some of them were breaking several times daily, furnishing a constant source of annoyance. In building the new mill they were all made so strong that they were not calculated to break. The breaking box on top of the roll was made solid, as they were apt, when they gave way, to break the collars on the rolls, which should, if possible, be avoided. All these changes were stoutly opposed by the foremen and workmen of the mill. A few days before the mill was ready to start, the superintendent of the mill discovered that the breaking box was solid; he then got the pattern and took it to Mr. Lewis, the pattern-maker, and told him there was a mistake, that it was made solid. Mr. Lewis told him that it was made as the old man had ordered it, to which the superintendent said, "The old man has gone crazy." He looked me up and wanted to know if I had ordered the breaking box for the new train solid. I said, "Yes;" he replied that if with solid spindles, heavy coupling boxes and solid breaking boxes on top of the rolls, a piece should enter a wrong groove, or a collar should form on the rolls, which was sure to take place, the mill would be broken to pieces; to which I replied: "I would rather have a grand old smash-up once in a while than be continually breaking something and keeping the mill standing half the time and the metal wasting in the furnace." He said: "Well, you will get it, sure;" but we did not, and, as before stated, the mill made 30,000 tons of rails without a break of any kind, which, at that time, on iron, was nearly a year's work.

The heating furnaces were rebuilt, making them larger, the roofs much higher, and the length of the furnace greatly increased, which about doubled the work that had previously been done. There were also a number of improvements made on the train to facilitate the work, and make it much easier for the men. Among them was the introduction of the driven feed-roller, out of which, later on, came the blooming table, which is now indispensable in the rolling of steel ingots either on a three-high or reversing mill.

(To be continued.)

A UNIQUE IMPULSE WHEEL GENERATING PLANT.

IN the pumping station of the city of Columbus, Ohio, a plant has been installed by the American Impulse Water Wheel Company, of New York, which is unique in character, and which presents a number of interesting engineering features.

The Director of Public Improvements, finding that the pumping capacity of the station was greater than the city's needs, cast about him for some means of utilizing this surplus power, and hit upon the idea of using the surplus water that the pumps were capable of supplying, to drive water wheels directly connected with dynamos, the current thus generated being used for supplying light to the arc lamps in the surrounding district.

Specifications were accordingly prepared and submitted to the leading water wheel manufacturers, with the result that the plan proposed by the American Impulse Water Wheel Company was accepted as the one giving the best promise of fulfilling the requirements.

The specifications were very rigid in their requirements with regard both to efficiency at all loads and to speed governing under sudden and great changes of load. The difficulty of the problem was also much enhanced by reason of the very limited space available for the machines and piping, and by the high speed required for direct connection with the Western Electric Company's 100-light arc dynamo, selected by the engineer in charge. This speed, 650 r. p. m., necessitated the use of impulse wheels only 18 inches in diameter, and in order to obtain 110 H.P. from each unit 18 nozzles were required. These were arranged with 6 runners, 3 nozzles to each runner, since a larger number of nozzles per runner would have reduced the efficiency below that required.

The use of contracting nozzles to keep up the efficiency at light loads was prohibited by the great cost and complexity of the construction. Ordinary butterfly valves were accordingly used, and the cam mechanism for operating these valves, shown in Figs. 1 and 2, arranged to actuate them one after the other instead of all together, as had previously been common practice. As a result of this ingenious arrangement, all the valves in operation, except one, would be wide open and working, therefore, at their maximum efficiency, and thus the low efficiency of a partly closed butterfly valve would have an almost inappreciable effect in lowering the total jet efficiency of the machine, and at six values of the load, when a valve had just completely closed, would have no such effect at all.

The rigid requirements with regard to efficiency having been thus complied with, the problem of speed governing was next attacked. The small diameter of the runners, rendered necessary by the high speed, so far reduced their momentum that it was necessary to add a heavy fly wheel in order to keep the variations of speed within the guaranteed limits. The high speed also prohibited the use of the ordinary cast iron fly wheel. The wheel was accordingly made with a steel rim shrunk onto a cast iron web. The governor is the ordinary mechanical relay actuating six cams as shown in Figs. 1 and 2, the connection between the cam shaft and the governor being by gear and pinion.

The water chambers were cast in two pieces as shown in Fig. 2, the nozzles being bolted on so as to come in exactly the right position with reference to the runners. This large casting was bolted on the cast iron base. The casing was made of riveted boiler iron in two parts, the upper half being provided with eye bolts for lifting. The details of the piping, receiver, etc., are clearly enough shown in the accompanying illustrations.

The fact that this plant has now been running for over twelve months without trouble of any kind, and

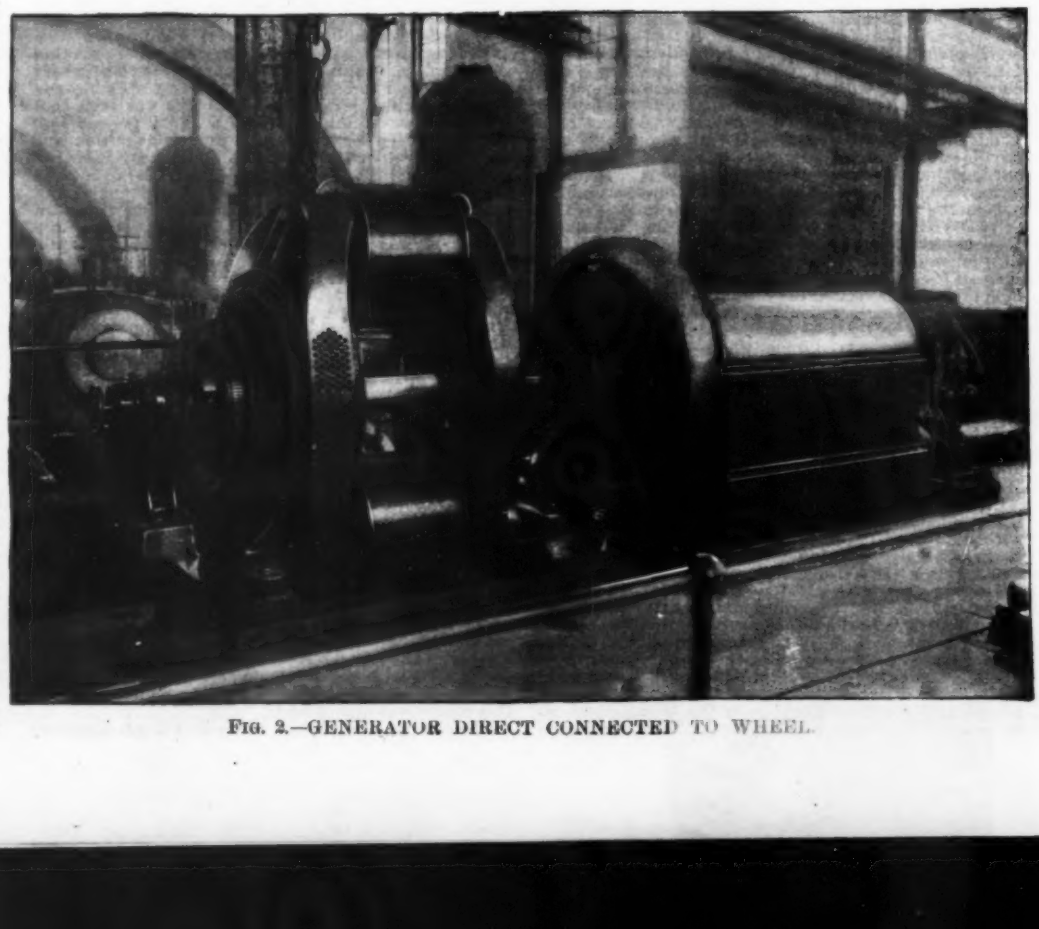


FIG. 2.—GENERATOR DIRECT CONNECTED TO WHEEL.

to the entire satisfaction of the engineer in charge, reflects great credit upon the engineers of the company.

THE TRANSMISSION OF ELECTRICAL ENERGY.

IF an electric current pass through a conductor, all its energy is expended in the full circuit. Part of the circuit may be an electrical generator which supplies energy as fast as it is expended. Part of the circuit may be a motor which absorbs some of the energy, the rest being expended in forcing a current through the connecting wires and through the generator. The electric energy in the generator and connecting wires is uselessly expended by conversion into heat. That in the motor is largely utilized by conversion into mechanical energy. This represents the transmission of energy.

Although the electric motor, whereby electrical energy is converted into mechanical energy, was invented long ago, it has been practically applied only in very recent times. That the motor was not immediately used in the performance of work is due largely to the fact that formerly galvanic batteries employing

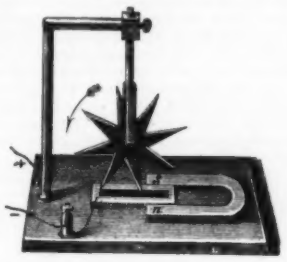


FIG 1.—BARLOW'S WHEEL (1823).

costly zinc as one of the elements were the only source of electrical energy at hand. Now we use coal or water-power to drive dynamos which supply us with unlimited energy at a much smaller expense.

It is not definitely known who built the first electric motor. Behrens (1775–1813) constructed a perpetual motion machine driven by electricity derived from the transformation of chemical energy. The apparatus, says Stein der Weisen, comprised an electric pendulum suspended between the opposite poles of two dry batteries, which pendulum, under the influence of the attraction and repulsion of the poles, oscillated from side to side until the batteries were exhausted.

One of the earliest forms of electric motors is to be found in Barlow's wheel (1823). Between the poles, *n s* (Fig. 1), of a magnet a star wheel is so mounted that the lowermost point will dip into a mercury-vessel placed between the poles of the magnet. If the wheel and the mercury-vessel be connected with a source of electricity, the current will flow radially through the wheel and through the point which at the time is immersed in the quicksilver. By reason of the influence of the magnetic field, *n s*, the movable conductor will be caused to turn in the direction indicated by the arrow. Dr. Schultess, in 1832, proposed at a scientific gathering in Zürich the use of the power derived from the making and breaking of an electric circuit. A motor built upon this principle was exhibited to the same society in 1833, and was built by Salvatore Dal Negro, a professor at the University of Padua. From the investigations made by the Italian Commis-

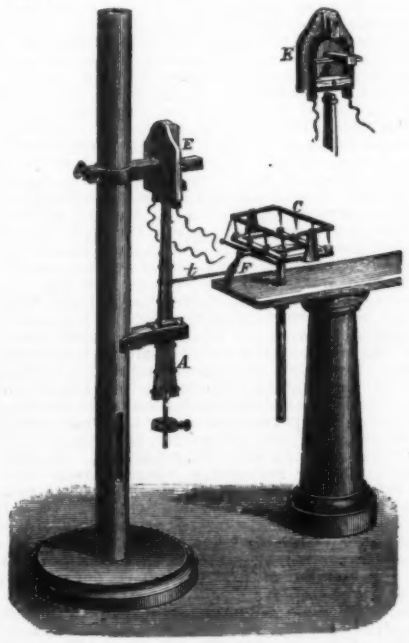


FIG. 2.—DAL NEGRO'S ELECTRIC MOTOR (1830).

sioners at the Paris Exposition of 1881, it would seem that Dal Negro's motor was constructed as early as 1830. The motor (Fig. 2) comprises a steel magnet, *A*, mounted to swing on an axis secured thereto at a point one-third of its length. Its upper end oscillates between the poles of an electromagnet, *E* (shown in detail). As soon as a current passes through the coils of the electromagnet, the end of the steel magnet, *A*, will be attracted to the oppositely-magnetized pole of the electromagnet and repelled by the similarly-magnetized pole. If the poles of the electromagnet be constantly changed, the pendulum will be continuously oscillated. The current is thus changed in direction by a commutator, *C*, which is set in operation by the rod, *t*, and the fork, *F*. This commutator, which forms part of the circuit of the electromagnet, changes the direction of the current whenever the permanent magnet approaches one of the electromagnetic poles. In 1831, Professor Henry, of Princeton University, built a motor which was the forerunner of all modern rotary motors and which was provided with an automatic pole-changer. The English electrician Joule has written:

"It is to the ingenious American philosopher that we are indebted for the first form of the working model of an engine upon the principle of reciprocating polarity of soft iron by electro dynamic agency."

In 1834 Jacobi constructed a motor, represented in Fig. 3, which, after having been considerably improved, was used in driving a boat on the Neva. Two series of electromagnets arranged in horse-shoe

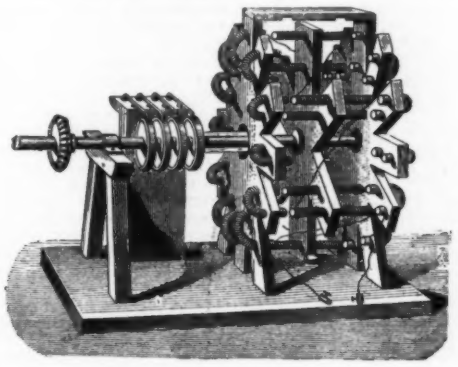


FIG. 3.—JACOBI'S ELECTRIC MOTOR (1834).

form are secured to two vertical frames. Between these frames is a horizontally-journaled, six-pointed star-wheel. Each of these points carries a pair of electromagnets parallel with the shaft of the wheel. On the shaft a four-disk commutator is mounted, which changes the direction of the current in the coils of the magnets whenever the straight electromagnets are opposite the poles of the horse-shoe magnets. If the straight magnets be between two successive horse-shoe magnets, then one of the latter will attract and the other repel the straight electromagnets. Hence, as soon as the terminals of the motor are connected with the poles of a battery, the star-wheel and the straight magnets will be rotated as long as the connection lasts. In 1842 Elias constructed a motor composed of two concentric iron rings, which were wound with insulated wire in such a manner that six magnetic poles were formed on each ring as soon as a current was passed through the winding. The outer ring was fixed. The inner ring was revolubly mounted on a horizontal shaft and received the current from a commutator secured to the shaft. The commutator changed the direction of the current whenever the poles of the inner ring were adjacent to the opposite poles of the fixed ring, so that the poles instead of being attracted were repelled, thus driving the inner ring on. For many years (1844–1862) Froment busied himself with electromotors. One of his most famous motors was built in 1845, and is represented in Fig. 4. Four pairs of electromagnets are radially mounted in a suitable frame; and between the poles of these magnets a wheel is arranged to turn, which is provided with a number of peripheral, soft-iron bars serving as the armatures of the magnets. The attraction of the armatures by the magnets causes the wheel to turn. The battery current is first conducted to a commutator, by which it is supplied successively and alternately to each pair of magnets. This commutator comprises a series of contacts

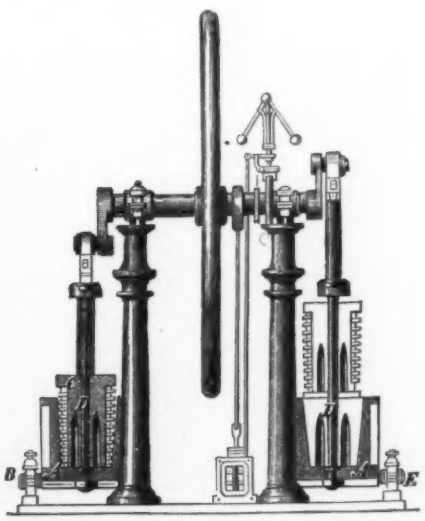


FIG. 5.—HJÖRTH'S ELECTRIC MOTOR (1849).

on the wheel-shaft, upon which small contact-blocks are spring-pressed. The commutator supplies current to the two pairs of electromagnets opposite which there happen to be armatures. This motor is still used as a toy or for experimental purposes in physical laboratories.

In 1849 Hjörth patented a motor which was awarded a gold medal at the London Exposition of 1851. Fig. 5 presents a side and partial end elevation of the motor. The electromagnets, *AA*, are conically hollowed and are mounted endwise on trunnions, *BE*, on which they oscillate. The electromagnets, *CC*, are conically shaped on their exteriors, are adapted to slide on the guide-rods, *DD*, and impart their motion to the fly-wheel shaft through the medium of cranks. Within the hollow magnets, *AA*, are extensions which fit in corresponding recesses of the magnets, *CC*. The motor is provided with a commutator resembling the slide-valve of a steam-engine, and like the latter is operated by an eccentric on the motor-shaft. This contrivance directs the current to one or the other of the two groups of electromagnets. The attraction exerted by the magnets, *A* and *C*, is more powerful than usual, owing to their peculiar construction. If in one group of magnets the movable magnet has reached the end of its motion, the commutator turns the current from this group into the other, whereby the

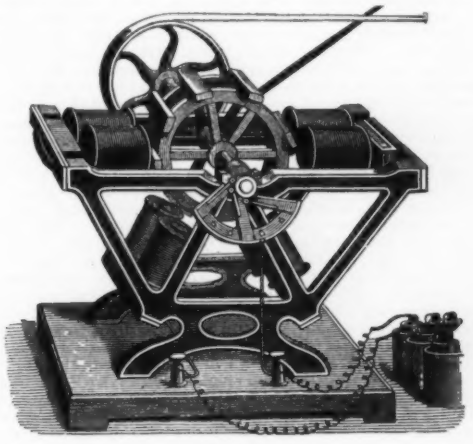


FIG. 4.—FROMENT'S ELECTRIC MOTOR (1845).

magnet, *C*, in the first group is moved up and the magnet, *C*, in the second group, down. The movement thus obtained is similar to that of the reciprocating steam-engine.

Of the older types of motors which employed solenoids, that of Page deserves especial attention. Two iron cores, *C* and *D* (Fig. 6), are suspended within solenoids, *A* and *B*, from the rods of a beam, *E G*, pivoted at *F*. The beam is provided with an extension to which a third rod is pivoted at *H*, which rod drives the flywheel by means of the crank, *K*. The eccentric, *L*, of the flywheel-shaft alternately directs the current from one solenoid to another. If the circuit is completed through *B*, the iron core, *D*, is drawn down into the solenoid and pulls the left end of the beam, *E G*, with it. When *D* has reached its lowermost position, the eccentric, *L*, cuts off the current through *B* and directs it to *A*. The iron core, *C*, is drawn down into *A*, and *B* rises again. Although the motor attracted no little attention at the time it first appeared, it was of no more practical value than its predecessors.

If the armature of a magneto-electric machine, the ring of a Gramme machine for example, be rotated, currents will be generated in the winding which can be employed for energizing electromagnets and for other purposes. The machine hence transforms mechanical work into electrical energy. But if, on the other hand, we connect the terminals of such a machine with a source of electricity, then the electric current will be compelled to pass through the winding of the machine. The electromagnets are hence energized and attract and repel the armature, which, as will be afterward explained, will rotate as long as current flows through the coils of the machine. The movement of the armature can be imparted to any machine by means of a belt and pulley, and is therefore employed in performing mechanical work. In this case the current, by means of the electric machine, is converted into mechanical work. This property of magneto-electric machines of converting electrical energy into mechanical energy and mechanical energy into electrical energy is termed reversibility.

It is by means of this principle of reversibility that a rational application of the electric motor or of the dielectric transmission of power is rendered possible. The principle is one which has been long known and is applied in almost every branch of science. We convert heat into motion (steam-engine); and by motion we can produce heat (friction). By heat, chemical

compounds are decomposed; and by combining substances to form chemical compounds, we produce heat. Every effect has a corresponding opposite effect.

The soundness of this principle for magneto-electric machines was first recognized by Pacinotti (1861) and clearly expressed by him. In 1867 Siemens remarked the reversibility of the machine. The reversibility of the Gramme machine was experimentally demonstrated in Paris on July 11, 1873. A public exhibition of the transmission of power was given by H. Fontaine at the Viennese Exposition in the same year. A Gramme machine was operated by a steam-engine and the resulting current conducted to a second machine, provided with steel magnets. The second machine was set in motion and made to drive a pump.

It was Fontaine's intention to drive the second Gramme, steel-magnet machine by a primary or Planté battery, in order to show that the Gramme machine could be used as an electric motor. After having endeavored to drive the machine by this method, it occurred to Fontaine to use part of the current of a large Gramme machine to operate the motor and thereby to drive a centrifugal pump which supplied water to a miniature waterfall. "When I saw," Fontaine tells us, "that the small magneto-electric machine, after having been connected with the dynamo, was not only set in motion, but also developed so much energy that the reservoir supplied by the centrifugal pump overflowed, I inserted wire until the quantity of water delivered became normal. The entire length of the wire was more than two kilometers; and it then occurred to me that by means of two Gramme machines it would be possible to transmit mechanical energy through great distances." According to Figuier, Fontaine's discovery of the transmission of power was partly accidental. Figuier states that a workman had connected the cable-ends of a Gramme machine supplying the current for the electric lights with an idle Gramme machine, under the impression that they belonged to the latter. The man was considerably astonished to see the second machine set in motion. Fontaine did not fail to exhibit this hitherto unobserved phenomenon to many persons.

The first practical application of transmission of electrical energy was made in the shops of St. Thomas d'Aquin in 1876. The artillery-officers were using a good dividing-engine which was automatic in operation, and could be stopped at any desired moment; this apparatus was to be driven by a steam-engine, but at some distance therefrom. The problem was solved by

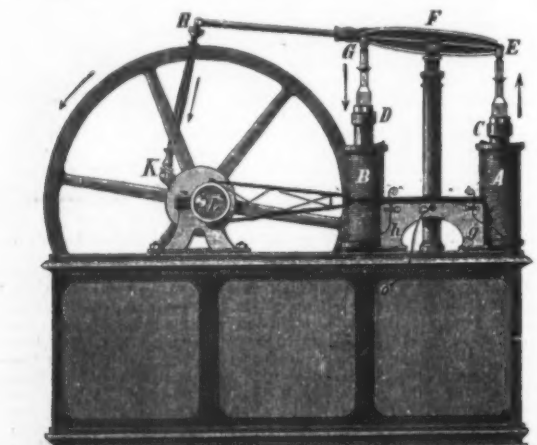


FIG. 6.—PAGE'S ELECTRIC MOTOR.

connecting the dividing-engine with a magneto-electric machine in turn connected by wires running over the court, with a Gramme machine driven by a steam-engine. The system proved successful almost from the beginning.

The second practical application of the transmission of electric energy was made by Cadiat, the engineer of the *Société du Val d'Osne*, in 1878. The power of one of the company's shops was obtained from an 8 horse-power steam-engine; while in a second workshop (for electro-plating) a portable engine was used to drive a Gramme machine. In the first of these workshops, Cadiat placed a Gramme machine, driven by the eight horse-power engine, and conducted his electric current through 150 meters (492 feet) of copper wire to a second Gramme machine in the electroplating shop to drive the electroplating dynamo, thus dispensing with the portable engine.

In the same year Chretian and Felix, engineers in the sugar-refinery of Sermaize (Departement Marne), installed an electric elevator to unload beet-laden ships; and in 1879 the same inventors devised a system of electric plowing.

Finally, Marcel Deprez proved experimentally that electric energy could be transmitted to great distances and stated that by means of high tension currents it would be possible to transmit power in this manner. Future developments have verified his predictions.

We shall now examine the processes involved in the electrical transmission of mechanical energy. The current generated by a dynamo-electric machine driven by any motor is conducted to a second machine which is set in motion and used in performing work. The first machine, which produces the current, we shall term the primary machine (the generator), and the second machine, which performs mechanical work, the secondary machine (receiver, electric motor). If the primary machine, I (Fig. 7), be rotated in the direction indicated by the arrow within the armature, currents will be induced in the magnets, *S* and *N*, so that positive electricity will be received by the brush, *a*. (For the sake of brevity and clearness, only the direction of the positive current will be considered.) From the brush, *a*, which represents the positive pole, the current passes to the coils of the electromagnets, thence to the secondary machine, II, and through the winding of its electromagnets, returning to the primary machine through *b*, which represents the negative pole. The current from the primary machine enters the secondary machine at *A*, passes around the first electromagnet in the direction of motion of the hands of a clock, hence imparting a south polarity to the magnet. If we follow the current in its course to the other electromagnets of the secondary machine, we shall find that the polarity of the upper magnet is north, and that of lower magnet south. When the current arrives at the brush, a_2, it is divided into two branch-currents, one of which passes through the upper half of the armature-winding, and the other of which flows through the lower half. The two branch-currents then reunite and emerge from the secondary machine by means of the brush, b_2. The ring-armature may hence be regarded as a spiral through which a current is flowing, or as a ring-shaped electromagnet which, owing to its position, is influenced by the powerful magnetic poles, N_2 and S_2.

How is the ring magnetized by the current? If, starting at a_2, we again observe the direction in which the current flows through the upper and lower halves of the armature, we shall find that the current passes through the upper half in the direction of the hands of a clock and through the lower half in a like direction. Hence at a_2 the magnetism of the ring must be south. If we study the current as it emerges at b_2, we shall find that here the magnetism is north. As a result of this magnetic division and of the influence of the poles, N_2 and S_2, the armature must turn to the right, as the arrow indicates. The north pole, N_2, attracts the south pole, a_2, and repels the north pole, b_2; while the south pole, S_2, repels the south pole, a_2, and attracts the north pole, b_2. If the current be constant, the secondary machine, II, will be uninterruptedly driven.

From Fig. 7 it will also be observed that the direction of motion of the secondary machine is opposed to that of the primary.

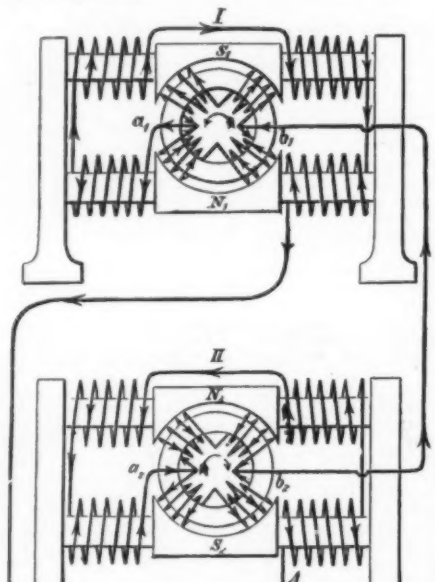


FIG. 7.—CONNECTED GENERATOR AND MOTOR.

In the secondary machine the armature turns between the two magnetic poles, N_2 and S_2; and the winding of the armature rotates in magnetic fields. Upon this principle the generation of electricity in magneto-electric machines depends. In the armature of the secondary machine currents must be induced as soon as the armature has been set in motion by the currents of the primary machine, since the method by which the armature is caused to rotate cannot affect the laws of induction. What will be the direction of these currents as a result of the armature's rotation? The electromagnets of the primary machine have a south pole at S_1 and a north pole at N_1; the armature is turned to the left, and hence a positive current must emerge at a_1. If the north and south poles of the electromagnets occupy the same relative positions in the secondary machine, then by reason of the armature's turning to the right (or in the direction opposite to that of the primary machine), the positive current must emerge at b_2; but since the poles of the magnets have been transposed, then the current induced in the armature of the secondary machine must emerge at a_2; and hence the current from the primary machine, entering at a_2, flows against the induced current. In two connected magneto-electric machines, one of which acts as a generator and the other as a receiver or motor, there will consequently be produced in the latter a counter-electromotive force.

After we have discovered that a counter-electromotive force is produced in the secondary machine, we naturally inquire what will be the effect of this force in the circuit formed by the two connected machines. If only the primary machine were in the circuit, the strength of the current, according to Ohm's law, would be equal to the electromotive force of the machine divided by the total resistance of the circuit. But when the secondary machine is also placed in the circuit and develops its counter-electromotive force, then this counterforce and the resistance of the second machine will both affect the strength of the current; and hence the strength of the current will be equal to the difference between the electromotive forces divided by the total resistance (resistance of both machines and of the conductor). If the total resistance remain unchanged, the strength of the current in the circuit must decrease as the counter-electromotive force increases. The electromotive force of a dynamo-electric machine depends upon the number of revolutions of its armature and the resistance of the circuit. We shall now explain the relation existing between two exactly similar dynamos connected as indicated in Fig. 7, the number of revolutions of the primary machine and the work performed by the secondary machine having unequal values.

Let it be assumed that the primary machine is making a certain number of revolutions. A galvanometer would show that the primary machine is generating currents, the strength of which gradually increases, as in all dynamos. These currents, as already shown, will set the secondary machine in motion. When it receives its current, the secondary machine, as we have also proved, will develop a counter-electromotive force increasing with the speed of the armature's rotation. As soon as the secondary machine is in operation, the galvanometer will show a constant diminution of current-strength. Since the rotative speed of the secondary machine must increase in proportion to the current-strength, then when the primary machine has acquired a fixed speed, the current-strength will reach its maximum. As we have assumed that the secondary machine is performing no work (the small amount of work done in overcoming friction can here be disregarded), the rotative speed of the secondary machine will evidently increase, as the electromotive force of the primary machine is greater than that of the secondary. But both machines are exactly similar; hence the secondary machine must develop an electromotive force equal to that of the primary machine, if it be rotating at the same speed. In other words, the strength of the current in the entire circuit is zero. This condition, also indicated by the galvanometer-needle, is very quickly realized when the two machines are connected as described.* This case is similar to that in which a dynamo runs with an open circuit. The machine uses up no energy; and the secondary machine performs no work.

Let us now consider the opposite case. The secondary machine is now required to perform considerable work; and in order to render the conditions entirely opposed to those already described, we shall assume that the ring of the secondary machine is held against rotation. In this case the secondary machine cannot develop a counter-electromotive force, and constitutes merely a circuit-closing arc of small resistance to the primary machine. Under such conditions the strength of the current increases rapidly, and the driving steam-engine will perform considerable work. And to what purpose is this work performed? It manifests itself in both machines in the form of heat, so that if the experiment be prolonged, the machines would be destroyed.

Let us now suppose that the secondary machine is to be made to perform work, for example, to lift a load. The primary machine now receives energy from the steam-engine and converts it into electrical energy; while the secondary machine receives this energy and performs work. In doing work the motion of the secondary machine is retarded in proportion to the increase of the amount of work (the lifting of a load) to be performed. Similarly, the counter-electromotive force must proportionately decrease, and consequently the strength of the current in the entire circuit must increase. If the amount of work performed by the secondary machine be small, its motion will be retarded only slightly, and the number of its revolutions will be almost equal to that of the primary machine, and hence the strength of the current in the entire circuit must be small. These conditions are similar to those first considered, in which the secondary machine had to perform no work at all. If the work done by the secondary machine be great, then the motion of the machine will be considerably retarded, and likewise the development of the counter electromotive force. Hence the strength of the current flowing through the circuit will be increased. If the work performed or energy developed be greater than the capacity of the secondary machine, then the latter will stop, and we have a condition of affairs similar to that considered in our second case, in which the secondary machine was held against rotation, the current strength being such that the machine would be destroyed by reason of the heat developed. The main current motor will therefore run more slowly when it has to do work. It must therefore be provided with some means whereby its motion may be regulated to conform with the amount and character of the work to be done.

The steam-engine which drives the primary machine operates in conformity with the secondary machine. If the amount of work to be done be small, then less power is required of the steam-engine. But when the secondary machine is overloaded and the armature, as a result, refuses to rotate, then more will be exacted of the steam-engine. In either case the secondary machine reproduces the energy transmitted by the steam-engine to the primary machine. Of course, the entire energy is never received at the secondary machine. Besides the friction and other resistances which have to be overcome, there is also the heating of the conductor by the electric current, whereby no small loss is incurred. Nevertheless, the efficiency of the electrical transmission of power is large when compared with other forms of power-transmission; and for this reason the electrical transmission of power is often one of the best methods to be employed.

Effect of Distance.—The heat developed in the circuit is directly proportional to the resistance and the strength of the current (Joule's law). The amount of energy transmitted depends upon the length of the circuit, and hence upon the length of the conductor connecting the primary and secondary machines, since the resistance varies with the length of the conductor. Consequently, the greater the distance between the primary and secondary machines, the greater will be the heat developed in the conductor, and the smaller the amount of energy transmitted. But the resistance is also inversely proportional to the cross-sectional area of the conductor. In order, therefore, not to lose energy in the form of heat, the conductor must be increased in thickness to correspond with the

* Experimentally only approximate results can be obtained, owing to the effort expended in overcoming friction and like resistance.

distance between the primary and secondary machines; for the resistance of a given conductor is equal to the resistance of a conductor of double the length and double the thickness. It is not difficult to see that this expedient is of no practical value when the distance between the two machines is great, because massive conducting rods would have to be employed, which are too expensive. To attain the desired end high tensions must be used. In order to generate high-tension currents, alternating-current dynamos are used which have no complicated collecting-brushes, whose insulation would be injured by the great voltage. When tensions greater than 3,000 or 4,000 volts are required, low-tension currents are first generated, transformed to the high tension required for long distance transmission, and again transformed at the end of the line down to the tension desired. The current is doubly transformed in order to preserve the insulation.

The question naturally arises: What is the advantage of the electric transmission of power? We need a motor to drive the primary machine, a secondary machine, and a conductor to connect the two machines. Hence there are two intermediary machines and the conductor, all of which present excellent opportunities for the loss of power. It will be said that it would be better to make the motor directly perform the work. It often happens that there is an abundance of power at one place and a lack of power at another. In transmitting this power electrically, we can perform needed work at the second place; and it is in such cases that the electric motor is particularly serviceable. Another application of the principle, one which is daily meeting with more favor, is the transmission of electrical energy from a central station to many separate distant stations where power is needed. To install separate machines at each of these sub-stations would be too costly. By establishing a central station with great steam-engines and generators, power can be economically produced and readily conducted to any desired place.

[Continued from SUPPLEMENT, No. 1249, page 20029.]

GEOGRAPHY.

OPENING ADDRESS BY SIR JOHN MURRAY, K.C.B., F.R.S., LL.D., PRESIDENT OF THE SECTION OF GEOGRAPHY OF THE BRITISH ASSOCIATION.

MARINE DEPOSITS ON THE OCEAN FLOOR.

THE marine deposits now forming over the floor of the ocean present many interesting peculiarities according to their geographical and bathymetrical position. On the continental shelf, within the 100-fathom line, sands and gravels predominate, while on the continental slopes beyond the 100-fathom line blue muds, green muds, and red muds, together with volcanic muds and coral muds, prevail, the two latter kinds of deposits being, however, more characteristic of the shallow water around oceanic islands. The composition of all these terrigenous deposits depends on the structure of the adjoining land. Around continental shores, except where coral reefs, limestones, and volcanic rocks are present, the materials consist principally of fragments and minerals derived from the disintegration of the ancient rocks of the continents, the most characteristic and abundant mineral species being quartz. River detritus extends in many instances far from the land, while off high and bold coasts, where no large rivers enter the sea, pelagic conditions may be found in somewhat close proximity to the shore line. It is in these latter positions that green muds containing much glauconite and other deposits containing many phosphatic nodules have for the most part been found; as, for instance, off the eastern coast of the United States, off the Cape of Good Hope, and off the eastern coasts of Australia and Japan. The presence of glauconitic grains and phosphatic nodules in the deposits at these places appears to be very intimately associated with a great annual range of temperature in the surface and shallow waters and the consequent destruction of myriads of marine animals. As an example of this phenomenon may be mentioned the destruction of the tile fish in the spring of 1882 off the eastern coast of North America, when a layer six feet in thickness of dead fish and other marine animals was believed to cover the ocean floor for many square miles.

In all the terrigenous deposits the evidences of the mechanical action of tides, of currents, and of a great variety of physical conditions, may almost everywhere be detected, and it is possible to recognize in these deposits an accumulation of materials analogous to many of the marine stratified rocks of the continents, such as sandstones, quartzites, shales, marls, green sands chalks, limestones, conglomerates, and volcanic grits.

With increasing depth and distance from the continents, the deposits gradually lose their terrigenous character, the particles derived directly from the emerged land decrease in size and in number, the evidences of mechanical action disappear, and the deposits pass slowly into what have been called pelagic deposits at an average distance of about 200 miles from continental coast lines. The materials composing pelagic deposits are not directly derived from the disintegration of the continents and other land surfaces. They are largely made up of the shells and skeletons of marine organisms secreted in the surface waters of the ocean, consisting either of carbonate of lime, such as pelagic mollusks, pelagic foraminifera, and pelagic algæ, or of silica, such as diatoms and radiolarians. The inorganic constituents of the pelagic deposits are for the most part derived from the attrition of floating pumice, from the disintegration of water-logged pumice, from showers of volcanic ashes, and from the débris ejected from submarine volcanoes, together with the products of their decomposition. Quartz particles, which play so important a rôle in the terrigenous deposits, are almost wholly absent, except where the surface waters of the ocean are affected by floating ice or where the prevailing winds have driven the desert sands far into the oceanic areas. Glauconite is likewise absent from these abysmal regions. The various kinds of pelagic deposits are named according to their characteristic constituents, pteropod oozes, globigerina oozes, diatom oozes, radiolarian oozes, and red clay.

The distribution of the deep-sea deposits over the floor of the ocean is shown on the map here exhibited, but it must be remembered that there is no sharp line of demarkation between them; the terrigenous pass gradually into the pelagic deposits, and the varieties of each of these great divisions also pass insensibly the one into the other, so that it is often difficult to fix the name of a given sample.

On another map here exhibited the percentage distribution of carbonate of lime in the deposits over the floor of the ocean has been represented, the results being founded on an extremely large number of analyses. The results are also shown in the table:

	Sq. Geo. Miles.	Percentage.
Over 75 per cent. $CaCO_3$....	6,000,000	5·8
50 to 75 " "	24,000,000	23·2
25 to 50 " "	14,000,000	13·5
Under 25 " "	59,000,000	57·5
	103,000,000	100

The carbonate of lime shells derived from the surface play a great and puzzling rôle in all deep-sea deposits, varying in abundance according to the depth of the ocean and the temperature of the surface waters. In tropical regions removed from land, where the depths are less than 600 fathoms, the carbonate of lime due to the remains of these organisms from the surface may rise to 80 or 90 per cent.; with increase of depth and under the same surface conditions the percentage of carbonate of lime slowly diminishes, till, at depths of about 2,000 fathoms, the average percentage falls to about 60, at 2,400 fathoms to about 30, and at about 2,600 fathoms to about 10, beyond which depth there may be only traces of carbonate of lime due to the presence of surface shells. The thin and more delicate surface shells first disappear from the deposits, the thicker and denser ones alone persist to greater depths. A careful examination of a large number of observations shows that the percentage of carbonate of lime in the deposits falls off much more rapidly at depths between 2,200 and 2,500 fathoms than at other depths.

The red clay, which occurs in all the deeper stretches of the ocean far from land and covers nearly half of the whole sea floor, contains, in addition to volcanic débris, clayey matter, the oxides of iron and manganese, numerous remains of whales, sharks, and other fishes, together with zeolitic crystals, manganese nodules and minute magnetic spherules, which are believed to have a cosmic origin. One haul of a small trawl in the Central Pacific brought to the surface on one occasion, from a depth of about two and a half miles, many bushels of manganese nodules, along with fifteen hundred sharks' teeth, over fifty fragments of ear bones, and other bones of whales. Some of these organic remains, such as the Carcharodon and Lamna teeth and the bones of the ziphioid whales, belong apparently to extinct species. One or two of these sharks' teeth, ear bones, or cosmic spherules, may be occasionally found in a globigerina ooze, but their occurrence in this or any deposits other than red clay is extremely rare.

Our knowledge of the marine deposits is limited to the superficial layers; as a rule, the sounding tube does not penetrate more than six or eight inches, but in some positions the sounding tube and dredge have been known to sink fully two feet into the deposit. Sometimes a red clay is overlaid by a globigerina ooze; more frequently a red clay overlies a globigerina ooze, the transition between the two layers being either abrupt or gradual. In some positions it is possible to account for these layers by referring them to changes in the condition of the surface waters, but in other situations it seems necessary to call in elevations and subsidences of the sea floor.

If the whole of the carbonate of lime shells be removed by dilute acid from a typical sample of globigerina ooze, the inorganic residue left behind is quite similar in composition to a typical red clay. This suggests that possibly, owing to some hypogene action, such as the escape of carbonic acid through the sea floor, a deposit that once was a globigerina ooze might be slowly converted into a red clay. However, this is not the interpretation which commends itself after an examination of all the data at present available; a consideration of the rate of accumulation probably affords a more correct interpretation. It appears certain that the terrigenous deposits accumulate much more rapidly than the pelagic deposits. Among the pelagic deposits, the pteropod, and globigerina oozes of the tropical regions, being made up of the calcareous shells of a much larger number of tropical species, apparently accumulate at a greater rate than the globigerina oozes in extra-tropical areas. Diatom ooze, being composed of both calcareous and siliceous organisms, has again a more rapid rate of deposition than radiolarian ooze. In red clay the minimum rate of accumulation takes place. The number of sharks' teeth, of ear bones, and other bones of cetaceans and of cosmic spherules in a deposit may indeed be taken as a measure of the rate of deposition. These spherules, teeth and bones are probably more abundant in the red clays, because few other substances there fall to the bottom to cover them up, and they thus form an appreciable part of the whole deposit. The volcanic materials in a red clay having, because of the slow accumulation, been for a long time exposed to the action of sea water, have been profoundly altered. The massive manganese iron nodules and zeolitic crystals present in the deposit are secondary products arising from the decomposition of these volcanic materials, just as the formation of glauconite, phosphatic, and calcareous and barytic nodules accompanies the decomposition of terrigenous rocks and minerals in deposits nearer continental shores. There is thus a striking difference between the average chemical and mineralogical composition of terrigenous and pelagic deposits.

It would be extremely interesting to have a detailed examination of one of those deep holes where a typical red clay is present, and even to bore some depth into such a deposit if possible, for in these positions it is probable that not more than a few feet of deposit have accumulated since the close of the Tertiary period. One such area lies to the southwest of Australia, and its examination might possibly form part of the programme of the approaching Antarctic explorations.

LIFE ON THE OCEAN FLOOR.

It has already been stated that plant life is limited to the shallow waters, but fishes and members of all the invertebrate groups are distributed over the floor of the ocean at all depths. The majority of these deep-sea animals live by eating the mud, clay, or ooze, or by catching the minute particles of organic matter which fall from the surface. It is probably not far from the truth to say that three-fourths of the deposits now covering the floor of the ocean have passed through the alimentary canals of marine animals. These mud-eating species, many of which are of gigantic size when compared with their allies living in the shallow coastal waters, become in turn the prey of numerous rapacious animals armed with peculiar prehensile and tactile organs. Some fishes are blind, while others have very large eyes. Phosphorescent light plays a most important role in the deep sea, and is correlated with the prevailing red and brown colors of deep-sea organisms. Phosphorescent organs appear sometimes to act as a bull's eye lantern to enable particles of food to be picked up, and at other times as a lure or a warning. All these peculiar adaptations indicate that the struggle for life may be not much less severe in the deep sea than in the shallower waters of the ocean.

Many deep-sea animals present archaic characters; still, the deep sea cannot be said to contain more remnants of faunas which flourished in remote geological periods than the shallow and fresh waters of the continents. Indeed, king crabs, Lingulas, Trigonias, Port Jackson sharks, Ceratodus, Lepidosiren, and Protopterus, probably represent older faunas than anything to be found in the deep sea.

Sir Wyville Thomson was of opinion that, from the Silurian period to the present day, there had been as now a continuous deep ocean with a bottom temperature oscillating about the freezing point of fresh water, and that there had always been an abyssal fauna. I incline to the view that in Palæozoic times the ocean basins were not so deep as they are now; that the ocean then had throughout a nearly uniform high temperature, and that life was either absent or represented only by bacteria and other low forms in great depths, as is now the case in the Black Sea, where life is practically absent beyond 100 fathoms, and where the deeper waters are saturated with sulphureted hydrogen. This is not, however, the place to enter on speculations concerning the origin of the deep sea fauna, nor to dwell on what has been called "bipolarity" in the distribution of marine organisms.

EVOLUTION OF THE CONTINENTAL AND OCEANIC AREAS.

I have now pointed out what appears to me to be some of the more general results arrived at in recent years regarding the present condition of the floor of the ocean. I may now be permitted to indicate the possible bearing of these results on opinions as to the origin of some fundamental geographical phenomena; for instance, on the evolution of the protruding continents and sunken ocean basins. In dealing with such a problem much that is hypothetical must necessarily be introduced, but these speculations are based on ascertained scientific facts.

The well known American geologist, Dutton, says: "It has been much the habit of geologists to attempt to explain the progressive elevation of plateaus and mountain platforms, and also the folding of strata, by one and the same process. I hold the two processes to be distinct, and having no necessary relation to each other. There are plicated regions which are little or not at all elevated, and there are elevated regions which are not plicated." Speaking of great regional uplifts, he says further: "What the real nature of the uplifting force may be is, to my mind, an entire mystery, but I think we may discern at least one of its attributes, and that it is a gradual expansion or a diminution of density of the subterranean magmas. . . . . We know of no cause which could either add to the mass or diminish the density, yet one of the two must surely have happened. . . . Hence I infer that the cause which elevates the land involves an expansion of the underlying magmas, and the cause which depresses it is a shrinkage of the magmas; the nature of the process is at present a complete mystery." I shall endeavor to show how the detailed study of marine deposits may help to solve the mystery referred to by Dutton.

The surface of the globe has not always been as we now see it. When, in the past, the surface had a temperature of about 400° F., what is now the water of the ocean must have existed as water vapor in the atmosphere, which would thereby—as well as because of the presence of other substances—be increased in density and volume. Life, as we know it, could not then exist. Again, science foresees a time when low temperatures, like those produced by Prof. Dewar at the Royal Institution, will prevail over the face of the earth. The hydrosphere and atmosphere will then have disappeared within the rocky crust, or the waters of the ocean will have become solid rock, and over their surface will roll an ocean of liquid air about 40 feet in depth. Life, as we know it, unless it undergoes suitable secular modifications, will be extinct. Somewhere between these two indefinite points of time in the evolution of our planet it is our privilege to live, to investigate, and to speculate concerning the antecedent and future conditions of things.

When we regard our globe with the mind's eye, it appears at the present time to be formed of concentric spheres, very like, and still very unlike, the successive coats of an onion. Within is situated the vast nucleus or centrosphere; surrounding this is what may be called the tektosphere (*τηκτός*, molten), a shell of materials in a state bordering on fusion, upon which rests and creeps the lithosphere. Then follow hydrosphere and atmosphere, with the included biosphere (*βίος*, life). To the interaction of these six geospheres, through energy derived from internal and external sources, may be referred all the existing superficial phenomena of the planet.

The vast interior of the planetary mass, although not under direct observation, is known, from the results of the astronomer and physicist, to have a mean density of 5·6, or twice that of ordinary surface rock. The substances brought within the reach of observation in veinstones, in lavas, and hypogene rocks—by the action of water as a solvent and sublimant—warrant the belief that the centrosphere is largely made up of metals and metalloids with imprisoned gases. It is admitted that the vast nucleus has a very high temperature, but so enormous is the pressure of the superincumbent crust that the melting point of the substances in the interior is believed to be raised to a higher value than the temperature there existing; the centrosphere in consequence remains solid, for it may be assumed that the melting point of rock-forming materials is raised by increase of pressure. Astronomers,

from a study of precession and nutation, have long been convinced that the centrosphere must be practically solid.

Recent seismological observations indicate the transmission of two types of waves through the earth—the condensational-rarefactional and the purely distortional—and the study of these tremors supports the view that the centrosphere is not only solid, but possesses great uniformity of structure. The seismological investigations of Profs. Milne and Knott point also to a fairly abrupt boundary or transition surface, where the solid nucleus passes into the somewhat plastic magma on which the firm upper crust rests.

In this plastic layer or shell—named the tektosphere—the materials are most probably in a state of unstable equilibrium and bordering on fusion. Here the loose textured solids of the external crust are converted into the denser solids of the nucleus or into molten masses, at a critical point of temperature and pressure; deep seated rocks may in consequence escape through fissures in the lithosphere. Within the lithosphere itself, the temperature falls off so rapidly toward the surface as to be everywhere below the melting point of any substance there under its particular pressure.

Now, as the solid centrosphere slowly contracted from loss of heat, the primitive lithosphere, in accommodating itself—through changes in the tektosphere—to the shrinking nucleus, would be buckled, warped, and thrown into ridges. That these movements are still going on is shown by the fact that the lithosphere is everywhere and at all times in a slight but measurable state of pulsation. The rigidity of the primitive rocky crust would permit of considerable deformations of the kind here indicated. Indeed, the compression of mountain chains has most probably been brought in this manner, but the same cannot be said of the elevation of plateaus, of mountain platforms, and of continents.

From many lines of investigation it is concluded, as we have seen, that the centrosphere is homogeneous in structure. Direct observation, on the other hand, shows that the lithosphere is heterogeneous in composition. How has this heterogeneity been brought about? The original crust was almost certainly composed of complex and stable silicates, all the silicon dioxide being in combination with bases. Lord Kelvin has pointed out that, when the solid crust began to form, it would rapidly cool over its whole surface; the precipitation of water would accelerate this process, and there would soon be an approximation to present conditions. As time went on, the plastic or critical layer—the tektosphere—immediately beneath the crust would gradually sink deeper and deeper, while ruptures and readjustments would become less and less frequent than in earlier stages. With the first fall of rain the silicates of the crust would be attacked by water and carbon dioxide, which can at low temperatures display silicon dioxide from its combinations. The silicates, in consequence, have been continuously robbed of a part or the whole of their bases. The silica thus set free goes ultimately to form quartz veins and quartz sand on or about the emerged land, while the bases leached out of the disintegrating rocks are carried out into the ocean and ocean basins. A continuous disintegration and differentiation of materials of the lithosphere, accompanied by a sort of migration and selection among mineral substances, is thus always in progress. Through the agency of life, carbonate of lime accumulates in one place; through the agency of winds, quartz sand is heaped up in another; through the agency of water, beds of clay, of oxides of iron, and of manganese are spread out in other directions.

The contraction of the centrosphere supplies the force which folds and crumples the lithosphere. The combined effect of hydrosphere, atmosphere, and biosphere on the lithosphere gives direction and a determinate mode of action to that force. From the earliest geological times the most resistant dust of the continents has been strewn along the marginal belt of the sea floor skirting the land. At the present time, the deposits over this area contain on the average about 70 per cent. of free and combined silica, mostly in the form of quartz sand. In the abysmal deposits far from land there is an average of only about 30 per cent. of silica, and hardly any of this in the form of quartz sand. Lime, iron, and the other bases largely predominate in these abysmal regions. The continuous loading on the margins of the emerged land by deposits tends by increased pressure to keep the materials of the tektosphere in a solid condition immediately beneath the loaded area. The unloading of emerged land tends by relief of pressure to produce a viscous condition of the tektosphere immediately beneath the denuded surfaces. Under the influence of the continuous shakings, tremors, and tremblings always taking place in the lithosphere, the materials of the tektosphere yield to the stresses acting on them, and the deep seated portions of the terrigenous deposits are slowly carried toward, over, or underneath the emerged land. The rocks subsequently reformed beneath continental areas out of these terrigenous materials, under great pressure and in hydrothermal conditions, would be more acid than the rocks from which they were originally derived, and it is well known that the acid silicates have a lower specific gravity than the intermediate or basic ones. By a continual repetition of this process the continental protuberances have been gradually built up of lighter materials than the other parts of the lithosphere. The relatively light quartz, which is also the most refractory, the most stable, and the least fusible among rock-forming minerals, plays in all this the principal role. The average height of the surface of the continents is about three miles above the average level of the abysmal regions. If now we assume the average density of the crust beneath the continents to be 2·5, and of the part beneath the abysmal regions to be 3, then the spheroidal surface of equal pressure—the tektosphere—would have a minimum depth of 18 miles beneath the continents and 15 miles beneath the oceans; or if we assume the density of the crust beneath the continents to be 2·5, and beneath the abysmal regions to be 2·8, then the tektosphere would be 28 miles beneath the continents and 25 miles beneath the oceans. The present condition of the earth's crust might be brought about by the disintegration of a quantity of quartz-free volcanic rock, covering the continental areas to a depth of 18 miles, and the reformation of rocks out of the disintegrated materials.

(To be continued.)

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